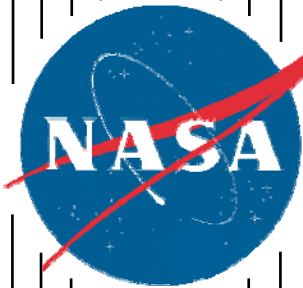


**National Aeronautics and
Space Administration
Dryden Flight Research Center
Edwards Air Force Base, California**



Environmental Restoration Program



**Record of Decision
Operable Unit 6**



FINAL

September 2006



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 95TH AIR BASE WING (AFMC)
EDWARDS AIR FORCE BASE, CALIFORNIA

17 January 2007

MEMORANDUM FOR SEE DISTRIBUTION

FROM: 95 ABW/CEVR
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SUBJECT: Final OU6 ROD

1. Transmitted herein is the final document entitled: *Record of Decision, Operable Unit 6*.
2. If you have any questions or comments, please call me at (661) 277-1474.

A handwritten signature in black ink, appearing to read "Ai Duong", is positioned above the printed name and title.

AI DUONG
Chief, Environmental Restoration Branch

Attachment:
Final OU6 ROD

DISTRIBUTION:

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Mr. J. Cass, California RWQCB, Lahontan Region (2 hard copies, 1 electronic copy on CD)
Mr. Pete Phillips, URS Corporation (1 hard copy)

ENVIRONMENTAL RESTORATION PROGRAM

RECORD OF DECISION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DRYDEN FLIGHT RESEARCH CENTER

OPERABLE UNIT 6

EDWARDS AIR FORCE BASE

CALIFORNIA

FINAL

SEPTEMBER 2006

Prepared for:

95TH AIR BASE WING
ENVIRONMENTAL MANAGEMENT DIVISION (95 ABW/CEV)
EDWARDS AIR FORCE BASE, CA 93524-8060

and

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
DRYDEN FLIGHT RESEARCH CENTER
SAFETY, HEALTH, AND ENVIRONMENTAL OFFICE
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and

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
INSTALLATION SUPPORT, AIR FORCE MATERIEL COMMAND (AFCEE/ISM)
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LIST OF ABBREVIATIONS AND ACRONYMS

95 ABW/CEV	95th Air Base Wing, Environmental Management Division
95 ABW/CEVR	95th Air Base Wing, Environmental Restoration Branch (formerly AFFTC/EMR)
95% UCL	95 percent upper confidence limit
%	percent
µg/L	micrograms per liter
acre-ft	acre-foot
AFB	Air Force Base
AFCEE/ERD	Air Force Center for Environmental Excellence, Environmental Restoration Division
AFCEE/ISM	Air Force Center for Environmental Excellence/Installation Support, Air Force Materiel Command
AFFTC/EMR	Air Force Flight Test Center, Environmental Restoration Division
AOC	area of concern
APU	auxiliary power unit
ARAR	applicable or relevant and appropriate requirement
AS	air sparge
AVEK	Antelope Valley–East Kern Water Agency
Basin Plan	Water Quality Control Plan for the Lahontan Region
bgs	below ground surface
BNSF	Burlington Northern Santa Fe
CCR	California Code of Regulations
CDWR	California Department of Water Resources
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Co.	county
COC	chemical of concern
COPEC	contaminant of potential ecological concern
CRWQCB	California Regional Water Quality Control Board
DFRC	Dryden Flight Research Center
DHS	Department of Health Services
DTSC	Department of Toxic Substances Control
Earth Tech	Earth Tech, Inc.
e.g.	<i>exempli gratia</i> , for example
EIAP	Environmental Impact Assessment Process
ERP	Environmental Restoration Program
ESI/RFA	Expanded Source Investigation/RCRA Facility Assessment
et seq.	<i>et sequentes</i> , and the following
FFA	Federal Facility Agreement
FR	field replicate
FS	Feasibility Study
GIS	geographic information system
GP	General Plan

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

gpm	gallons per minute
HB&A	Higginbotham/Briggs & Associates
HDSC	hazardous distribution service center
HHRA	Human Health Risk Assessment
IC	institutional control
i.e.	<i>id est</i> , that is
Jct.	junction
K-12	kindergarten through 12 th grade
lb	pound
LUC	land use control
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MP	Master Plan
NA	not analyzed
NAPL	nonaqueous phase liquid
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	not detected
NPL	National Priorities List
NRC	National Research Council
O&M	operation and maintenance
OU1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
OU4	Operable Unit 4
OU5/10	Operable Unit 5/10
OU6	Operable Unit 6
OU7	Operable Unit 7
OU8	Operable Unit 8
OU9	Operable Unit 9
PAH	polycyclic aromatic hydrocarbon
P.E.	professional engineer
PERA	Predictive Ecological Risk Assessment
Ph.D.	doctor of philosophy
POL	petroleum, oil, and lubricants
PP	Proposed Plan
ppb v/v	parts per billion volume per volume
PRG	preliminary remediation goal
RAB	Restoration Advisory Board
RAO	remedial action objective
RAR	relevant and appropriate requirement
RCRA	Resource Conservation and Recovery Act

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

RI	remedial investigation
RI Report	Remedial Investigation Report
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SERA	Scoping Ecological Risk Assessment
Sr.	senior
SVE	soil vapor extraction
SWRCB	State Water Resources Control Board
TCE	trichloroethene
TEFA	Technical and Economic Feasibility Analysis
TS	treatability study
UCL	upper confidence limit
UP	Union Pacific
U.S.	United States
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
U.S.C.	United States Code
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound

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1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Edwards Air Force Base (AFB), Kern, Los Angeles, and San Bernardino Counties, California, United States Environmental Protection Agency (USEPA) Identification Number: CA1570024504.

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy for Operable Unit (OU6) at Edwards AFB, California, which was chosen to satisfy the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for OU6. The Air Force and the USEPA are selecting this remedy in concurrence with the California Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board (CRWQCB).

1.3 ASSESSMENT OF OPERABLE UNIT 6

This Record of Decision (ROD) documents the response action to restore groundwater impacted by various chlorinated and aromatic hydrocarbons. The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

The groundwater beneath OU6 exceeds the acceptable risk range if people were to use it as their drinking water supply. Likewise, unacceptable risks exist for workers that may come into contact with the groundwater and/or inhale vapors from it. The groundwater beneath OU6 is designated as a potential drinking water source, and there are applicable or relevant and appropriate requirements (ARARs) that provide protective cleanup standards, namely, federal and state maximum contaminant levels (MCLs). The specific contaminants to be addressed by this ROD and cleanup standard for each

contaminant are provided in Table 2-2 to this ROD. Should the groundwater at OU6 ever be used for drinking, it would pose a potential risk to human health. This ROD also documents the decision that No Action is necessary for soils to protect public health or welfare or the environment.

1.4 DESCRIPTION OF THE SELECTED REMEDY

The overall OU6 groundwater cleanup strategy involves: (1) the injection of chemical oxidation reagents into groundwater to degrade chlorinated hydrocarbon contaminants, and (2) the enhanced natural attenuation of aromatic hydrocarbon contaminants to completely restore groundwater quality to concentrations below MCLs listed in Table 2-2 of this ROD. This action is intended to be the final action for OU6 and is addressed independently of other operable units at Edwards AFB. A decision of No Action is selected for OU6 soils.

No groundwater contaminant sources were identified in soil during investigation activities (Earth Tech, Inc. [Earth Tech], 2000). The NCP establishes an expectation that treatment will be used to address principal threats posed by the sites wherever practicable. Because no source materials were identified at OU6, no principal threat wastes were targeted for treatment at OU6.

The main components of the selected remedy include:

- Implement, monitor, maintain, enforce, and report land use controls on groundwater in accordance with the Base General Plan (GP) and National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC) Master Plan (MP)
- Treatment of high concentration portions of the chlorinated hydrocarbon plume via *in situ* chemical oxidation
- Treatment of high concentration portions of the aromatic hydrocarbon plume via enhanced natural attenuation (bioremediation)
- Demonstrate the effectiveness of natural attenuation at low concentration areas of the groundwater plume (Plume Containment) through periodic groundwater monitoring, and document reduction in contaminant levels throughout the plume
- Conduct CERCLA 5-year reviews to evaluate the effectiveness of the selected remedy

The Air Force, as a federal entity and lead agency for this CERCLA action, is solely responsible for implementation of the remedy. The Air Force will enter into agreements with NASA, the operator of the facility, to ensure implementation of all necessary institutional controls and use restrictions and to assist in monitoring and review of remedial actions. Although the Air Force may transfer certain

procedural responsibilities to NASA by contract or through other means, the Air Force shall retain ultimate responsibility for remedy integrity.

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy. It reduces the toxicity and volume of contaminants through treatment. This remedy will not result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unrestricted use and unrestricted exposure (i.e., residential levels). However, because the remedy will take more than 5 years to complete, a review will be conducted within 5 years after initiation of remedial action, and at subsequent 5-year intervals thereafter, as long as hazardous substances remain at the site above residential levels. The 5-year reviews are required to determine whether the remedy continues to be protective of human health and the environment.

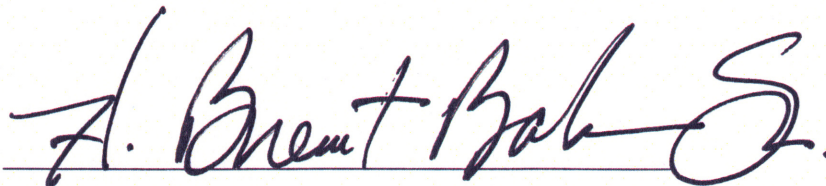
1.6 RECORD OF DECISION DATA REFERENCE LIST

The data reference list provided in Table 1-1 identifies the locations of certain key remedy selection information within the Decision Summary. Other relevant documents can be found in the Administrative Record.

TABLE 1-1. RECORD OF DECISION DATA REFERENCE LIST

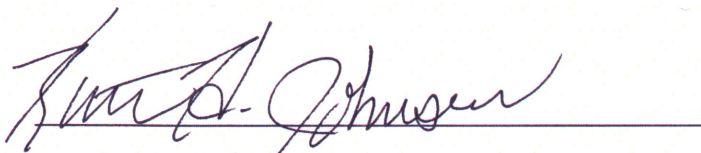
Key Remedy Selection Information	Document Section/Table Number
Chemicals of concern (COCs) and their respective concentrations.	2.5.4.3
Baseline risk represented by the COCs.	2.7
Cleanup levels (maximum contaminant levels) established for COCs and the basis for these levels.	2.5.4.3, 2.12.2.1, Table 2-2, and Table 2-4
How source materials constituting principal threats are addressed.	2.11
Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and record of decision.	2.6
Potential land and groundwater use that will be available at OU6 as a result of the selected remedy.	2.12.4
Estimated capital, annual operation and maintenance, and total present value costs, discount rate, and the number of years over which the remedy cost estimates are projected.	2.12.3.1
Key factor(s) that led to selecting the remedy.	2.12.1, 2.12.2, 2.12.3, and 2.12.4

1.7 AUTHORIZING SIGNATURES AND SUPPORT AGENCY ACCEPTANCE OF
REMEDY



Date 25 Sept 06

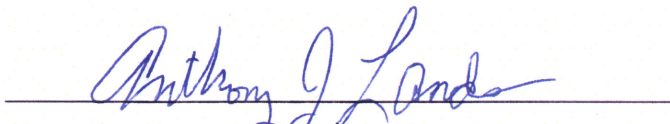
H. BRENT BAKER, SR., Colonel, USAF
Commander, 95th Air Base Wing
Edwards Air Force Base, California



Date 9/28/06

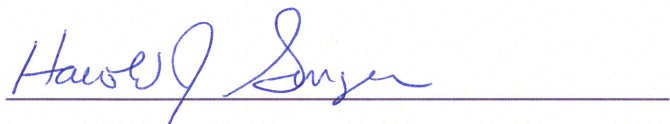
KATHLEEN H. JOHNSON
Chief, Federal Facilities and Site Cleanup Branch
U.S. Environmental Protection Agency, Region 9

The State of California, Department of Toxic Substances Control and the California Regional Water Quality Control Board, Lahontan Region had an opportunity to review and comment on this Record of Decision, and our concerns were addressed.



Date 10-19-06

ANTHONY J. LANDIS, P.E.
Chief, Northern California Operations
Office of Military Facilities
California Department of Toxic Substances Control

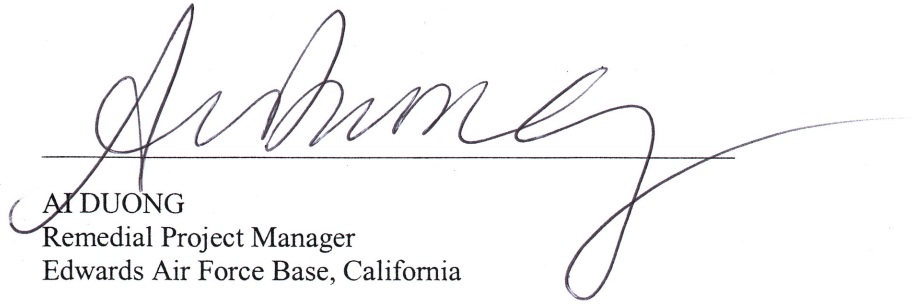


Date Dec 28, 2006

HAROLD J. SINGER, P.E.
Executive Officer
California Regional Water Quality Control Board
Lahontan Region

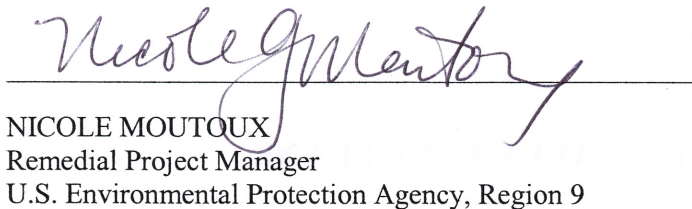
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We the undersigned, having worked on development of all phases of this document, hereby concur with all elements of this Record of Decision.



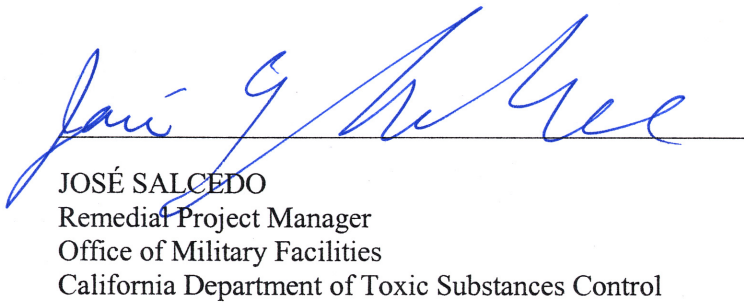
AI DUONG
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U.S. Environmental Protection Agency, Region 9

Date 3 Oct 06



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Remedial Project Manager
Office of Military Facilities
California Department of Toxic Substances Control

Date 3/oct/06

KAI DUNN, Ph.D., P.E.
Remedial Project Manager
California Regional Water Quality Control Board, Lahontan Region

Date _____

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2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

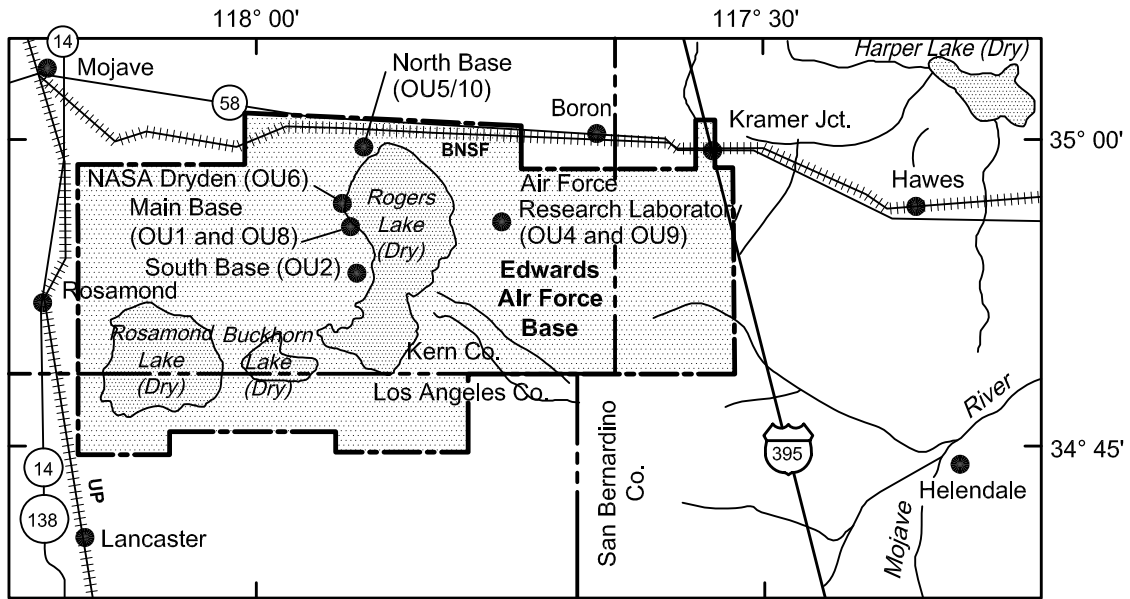
Edwards AFB is located in the Southern California counties of Kern, Los Angeles, and San Bernardino, approximately 5 miles northeast of the city of Lancaster (Figure 2-1). The Edwards AFB Comprehensive Environmental Response, Compensation and Liability Information System database USEPA Identification Number is CA1570024504. NASA DFRC, a tenant organization at Edwards AFB, is designated Environmental Restoration Program (ERP) OU6 and is located in the north-central portion of the Base on the main flightline, which is wholly within Kern County. See Figure 2-1 for the location of OU6. The responsible party and lead agency for OU6 activities is the United States Air Force (USAF). NASA is the funding entity. USEPA has a remedy selection role and oversight role for the cleanup. In addition to the USEPA, the regulatory agencies include the California DTSC and the CRWQCB. OU6 is part of a military base and is utilized for research, development, testing, and evaluation of aerospace systems. Three sites within the NASA DFRC boundary (Sites N2, N3, and N7) are considered to be the original source areas of the current OU6 groundwater solvent plume.

2.2 SITE ENFORCEMENT ACTIVITIES AND HISTORY

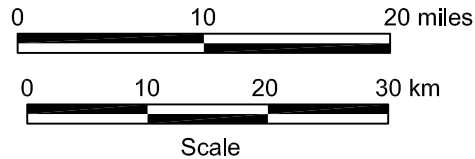
Following Edwards AFB's formal listing on the National Priorities List (NPL) on 30 August 1990, the USAF entered into a Federal Facility Agreement (FFA) with the USEPA, California DTSC, and CRWQCB. The FFA establishes the process for involving the USEPA and the State and the public in the Edwards AFB remedial response process. It provides a procedural framework for developing, implementing, and monitoring response actions at Edwards AFB in accordance with CERCLA; SARA; the NCP; pertinent provisions of the Resource Conservation and Recovery Act (RCRA); and applicable or relevant and appropriate state laws.

In 1980, the Department of Defense issued guidelines to investigate and clean up wastes from past operations at military installations worldwide. Shortly afterward, the Air Force began investigating its bases under the Department of Defense ERP, with the goal of protecting human health and the

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Base from U.S. Geological Survey State of California (South Half) 1:500,000



FINAL

Edwards Air Force Base Location Map

Date 09-2006

Project No.
54212

**Operable Unit 6
Record of Decision
Edwards AFB**

Figure

2-1

environment. The ERP at Edwards AFB is a localized version of the Department of Defense program with active participation from the USEPA and the State of California. The ERP is managed and implemented by the Environmental Restoration Branch, under the 95th Air Base Wing, Environmental Management Division.

In response to Edwards AFB's listing on the NPL and to facilitate the investigation of wastes from past military and/or tenant agency use and implement response actions, the Base was divided into 10 operable units. The operable units are defined by lease boundaries, if applicable; geographical location; similarities in contaminant types and distribution; and/or hydrologic setting. OUs 1, 6, and 8 are located in the Main Base area; OU2 is located in the South Base area; OU3 consists of abandoned or no longer required water wells located throughout the Base; OUs 4 and 9 are located in the Air Force Research Laboratory area; OU5/10 is located in the North Base area (formerly OUs 5 and 10); and OU7 includes miscellaneous/individual sites located outside of the other OUs. OU6 is defined by NASA DFRC's lease boundary.

NASA DFRC has leased a portion of the Edwards AFB flightline for 60 years (since 1946) supporting Space Shuttle, flight testing, and aeronautical research operations. During that time, workers performed test, evaluation, and maintenance activities involving toxic and hazardous materials. These materials often spilled and soaked into the ground or were disposed of inappropriately. Current use and disposal of these materials are strictly regulated to prevent releases to the environment. However, the following two past practices most likely resulted in releases to the environment at NASA DFRC: drum and underground tank storage of fuels and solvents; and use of coating-related materials (paints, thinners, strippers, and plating materials) in aircraft operation and maintenance.

In 1981, a preliminary assessment was performed for Edwards AFB, and a brief preliminary assessment and site inspection study was conducted at NASA DFRC in 1988. From 1991 to 1993, a comprehensive Expanded Source Investigation/RCRA Facility Assessment (ESI/RFA) was performed and covered the entire Base, including the NASA DFRC facilities. The ESI/RFA involved the assessment and inspection of over 1,000 features from small hazardous waste storage facilities to large-multiple story aircraft hangar/maintenance facilities. Based on the results of the ESI/RFA, 20 sites and/or areas of concern (AOCs) were identified within OU6 as contaminated or potentially contaminated.

2.2.1 SITES REMOVED FROM THE CERCLA PROCESS

Of the 20 OU6 sites or AOCs, 10 sites were eliminated after the Site Inspection Study phase because “no significant contamination” was identified through investigative activities such as soil and groundwater sampling, and 4 sites were removed from the CERCLA process because they were petroleum-only, consistent with the CERCLA petroleum exclusion. The remaining six sites (Sites N1, N2, N3, N4, and N7, and AOC N14) were retained for further study and evaluation and a decision for these sites will be made and documented in this ROD.

Detailed information for each Site/AOC is available in the OU6 Remedial Investigation Report (RI Report) (Earth Tech, 2000) and in previously issued Site/AOC reports referenced in the RI Report (Earth Tech, 2000). These documents are included in the Administrative Record for OU6 maintained at the 95th Air Base Wing, Environmental Management Division, 5 East Popson Avenue, Building 2650A, Edwards AFB, California, 93524.

2.2.2 SITES ADDRESSED IN THIS ROD

This decision document addresses the six sites remaining in the CERCLA process. Table 2-1 provides a decision summary for the six sites. The groundwater at the six sites will be addressed as a single commingled plume associated with the original source areas Sites N2, N3, and N7. The soils at Sites N1, N2, N3, N4, and N7, and AOC N14 have been recommended for No Action, and the selection of No Action is further explained and justified in this ROD.

2.2.2.1 Further Action for Groundwater

All of the chlorinated solvents and aromatic hydrocarbons detected in groundwater at OU6 are addressed in this ROD as a single commingled plume associated with Sites N2, N3, and N7. Analytical results associated with groundwater investigations are summarized in Section 2.5.4.3. Site and AOC locations are presented on Figure 2-2.

TABLE 2-1. DECISION SUMMARY FOR SITES ADDRESSED IN THIS ROD

Site/Area of Concern	Groundwater	Soil
N1	No Action Required. Addressed as commingled plume associated with Sites N2, N3, and N7.	No Action Required.
N2	Action Required. Addressed as commingled plume associated with Sites N2, N3, and N7.	No Action Required.
N3	Action Required. Addressed as commingled plume associated Sites N2, N3, and N7.	No Action Required.
N4	No Action Required. Addressed as commingled plume associated with Sites N2, N3, and N7.	No Action Required.
N7	Action Required. Addressed as commingled plume associated with Sites N2, N3, and N7.	No Action Required.
N14	No Action Required. No contamination found.	No Action Required. No contamination found.

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The OU6 Feasibility Study (FS) (Earth Tech, 2004) and this ROD, as part of the remedial response process, addresses the following three sites:

- Site N2 (ERP Site 206 – Former Auxiliary Power Unit [APU] Drainage Area)
- Site N3 (ERP Site 207 – Building 4889 Former Gas Station and Former Drum Dispensing Areas)
- Site N7 (ERP Site 211 – Building 4827 Former Drum Storage Areas)

Site N2

Site N2, located south of Buildings 4801 and 4823, consists of approximately 1.5 acres known as the Building 4801 Former APU Drainage Area (Figure 2-3). The Former APU Drainage Area was built in 1958 and was used to contain wastes from the former APU test facility located to the southwest of the drainage area. It may have received runoff from the aircraft runup area formerly located on the concrete apron and ramp south and east of the former APU test facility.

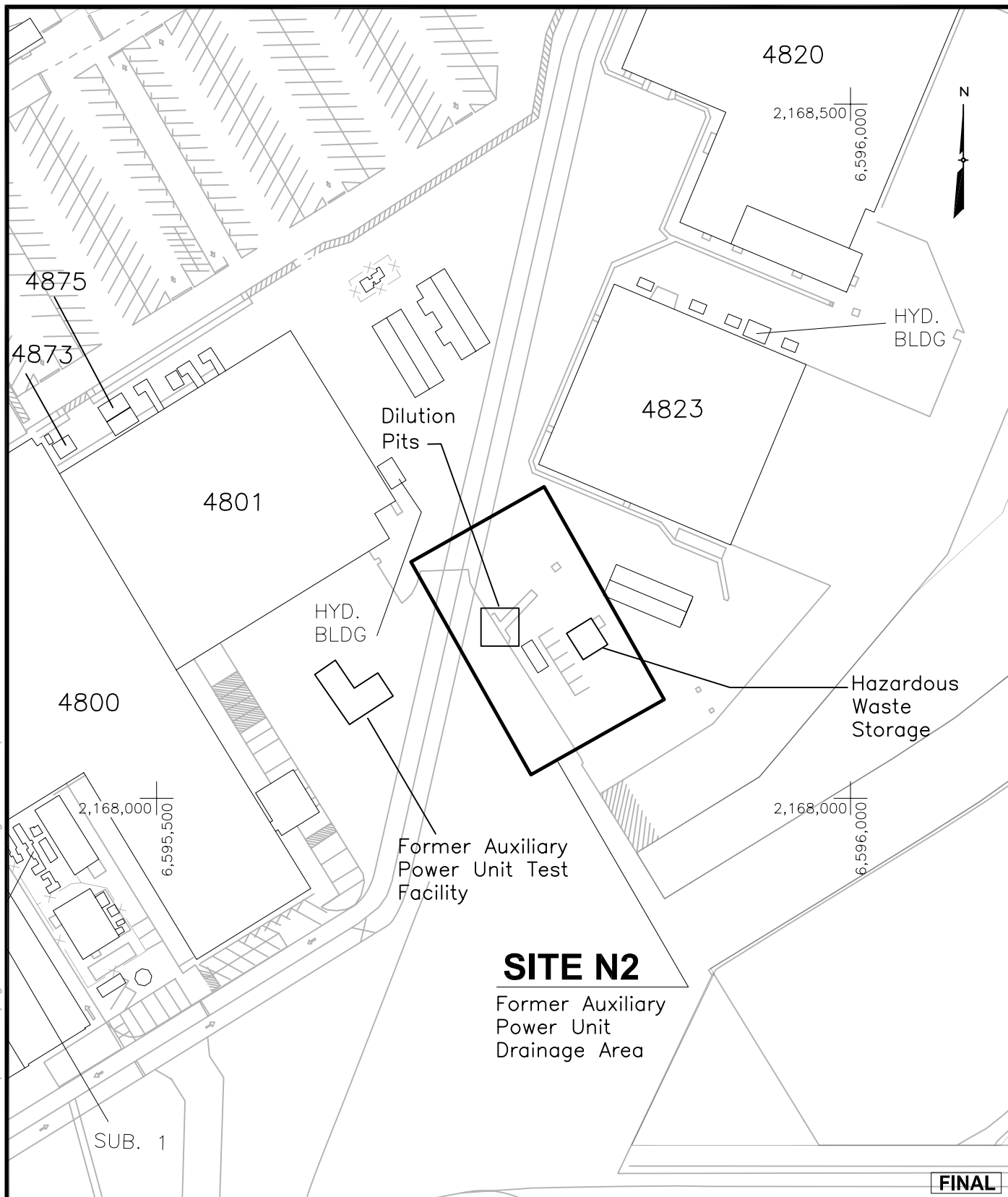
Site N2 also includes the Building 4801 Dilution Pits in the western half of the Former APU Drainage Area. The Dilution Pits, located northeast of the former APU test facility, consisted of three pits similar in construction to a three-chamber oil/water separator. The Dilution Pits were used to dilute hydrogen peroxide that drained from the former APU test facility. Potential wastes that may have been released at the Dilution Pits and the Former APU Drainage Area include hydrogen peroxide, solvents, jet fuel, and hydrazine from the former APU test facility and aircraft runup area, and chromium associated with runoff from the cooling tower blowdown. The Drainage Area and Dilution Pits were covered with pavement in 1962 and are no longer used for waste containment or disposal.

Site N3

Site N3 is the site of a former gas station (Figure 2-4) and contains Buildings 4889, 4886, 4803, and 4858, as well as two former drum dispensing areas. The Former Gas Station previously contained three underground storage tanks (USTs), which were removed in 1991. The tanks contained leaded and unleaded gasoline and jet fuel. The sources of the contaminant plume were likely a result of historical UST leakage as well as spillage of hazardous materials possibly including ethylene glycol, lubricating oil, degreasers, and solvents stored at the drum dispensing area from 1958 to 1993.

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L:\work\54212\CAD\OU6-ROD-FINAL-Sept. 2006\Figure 2-3 Site N2.dwg - 21 Sep 2006



EXPLANATION

— SITE N2 BOUNDARY

0 50 100

SCALE IN FEET

**Site Map
Site N2**

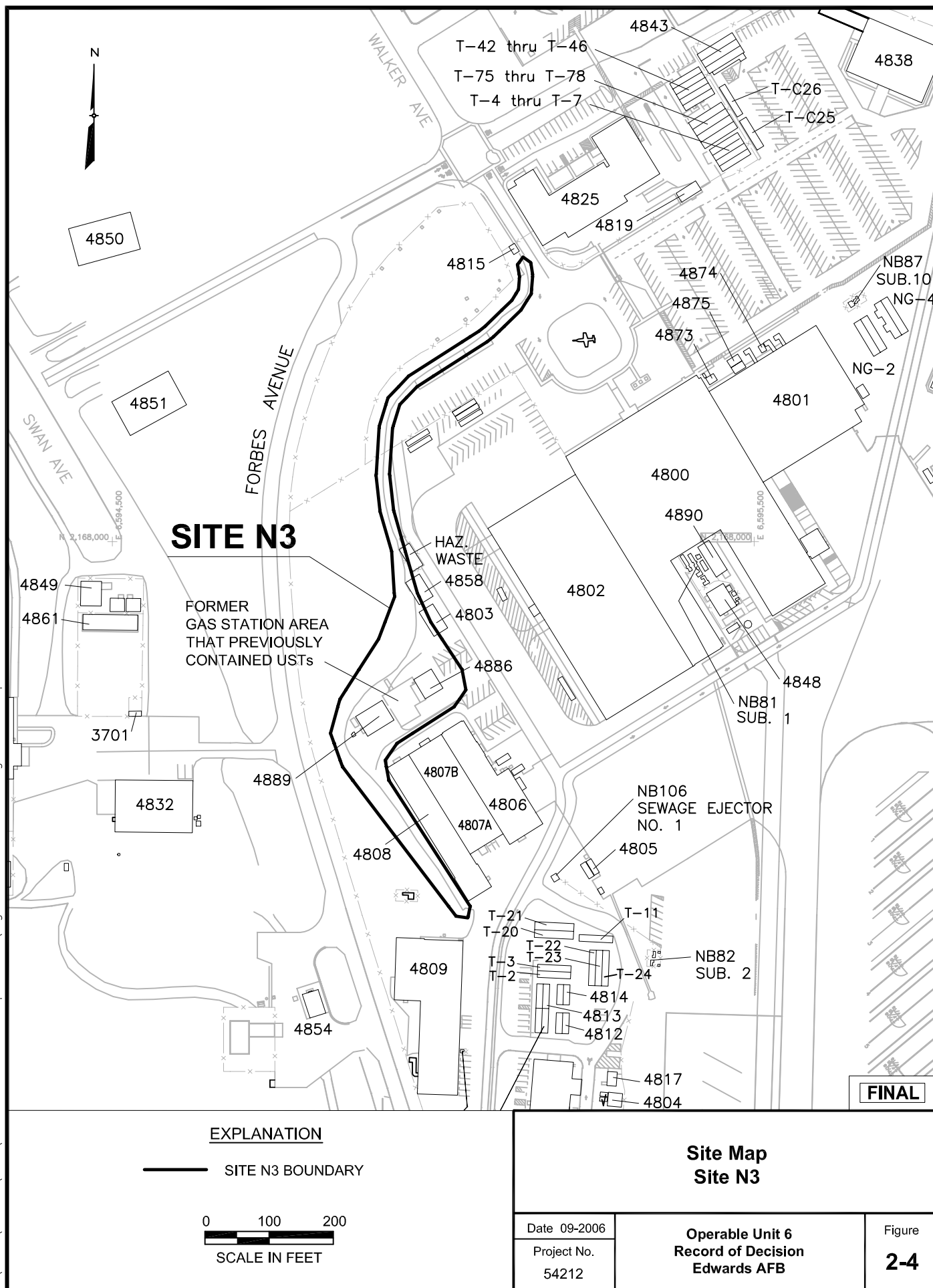
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Figure

2-3



Site N7

Site N7, Building 4827 Former Drum Storage Areas, is located south of Building 4827 (Figure 2-5). One drum storage area was located approximately 15 feet south of Building 4827, while a second drum storage area was located approximately 60 feet east of the first.

The storage areas where spills may have originated were reportedly used for storage of drummed hazardous materials and wastes such as paints; paint thinners; and petroleum, oil, and lubricants (POL). During a 1992 site visit, drums containing antifreeze, motor oil, and paint primer were observed. The drum storage areas were reportedly used prior to 1980 and up until 1993.

2.2.2.2 Soil Sites

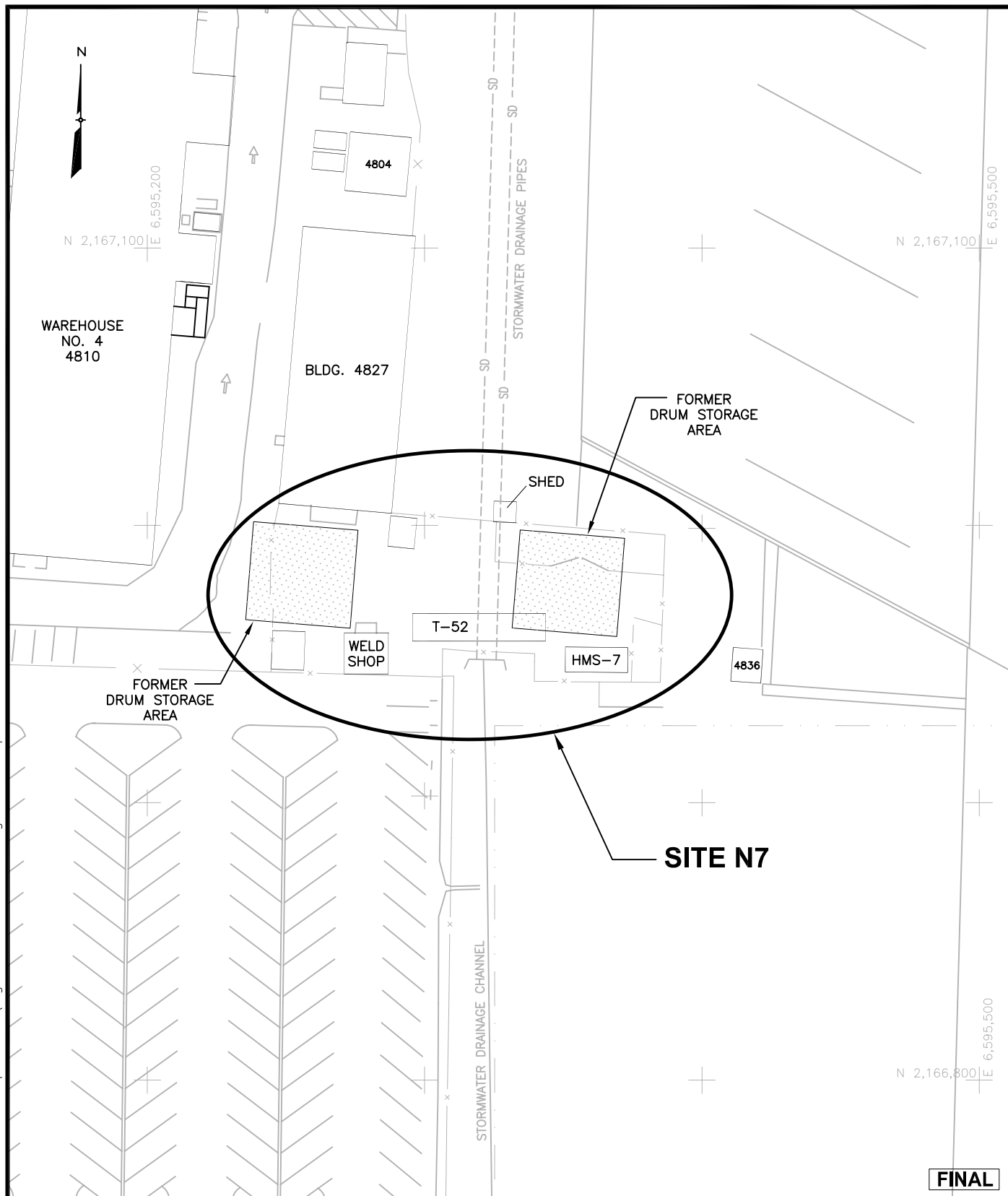
Sampling of surface and subsurface soils occurred at the suspected soil contamination areas at Sites N1, N2, N3, N4, and N7, and AOC N14 and the data were evaluated in the Human Health Risk Assessment (HHRA) (Earth Tech, 2003a). In addition, three of the six sites, Site N1, Site N4, and AOC N14 were further evaluated for potential risk to ecological receptors in the Predictive Ecological Risk Assessment (PERA) (Tetra Tech, 2003). For Site N1, Site N4, and AOC N14, the PERA documented that the risks determined to be of moderate ecological significance were reduced by the existence of low quality habitat (due to ongoing industrial activity) for all receptors. Sites N2, N3, and N7 were not evaluated in the PERA because no habitats or ecological receptors were identified at the sites.

Site N1

Site N1, the Northern Retention Pond, consists of a series of man-made, topographic depressions that lie along the eastern edge of OU6, and that were used to manage surface water runoff. The original Retention Pond area was comprised of a 14.5-acre area and was used as early as 1976. A portion of the retention pond is still in active use to manage surface water runoff originating from the northern portion of OU6, preventing direct outflow onto Rogers Dry Lake. Suspected contaminants included oil, lubricants, and solvents from the APU test facility near Building 4801; waste oil sprayed on the ground surface as dust control; aqueous film forming foam (fire suppressant); and chromium from cooling tower blowdown wastewater discharges.

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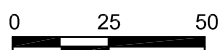
L:\work\54212\CAD\OU6-ROD-FINAL-Sept 2006\Figure 2-5 Site N7.dwg - 21 Sep 2006



FINAL

EXPLANATION

— SITE N7 BOUNDARY



SCALE IN FEET

**Site Map
Site N7**

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Figure

2-5

Site N2

Site N2, located south of Buildings 4801 and 4823, consists of approximately 1.5 acres known as the Building 4801 Former APU Drainage Area. The activities suspected of releasing hazardous substances to soil are discussed in the groundwater site discussion in Section 2.2.2.1.

Site N3

Site N3 is the site of a former gas station, as well as two former drum dispensing areas. The entire area is paved with either concrete or asphalt. The activities suspected of releasing hazardous substances to soil are discussed in the groundwater site discussion in Section 2.2.2.1.

Site N4

Site N4, the Southern Retention Pond, consists of an unlined, 4-acre area bounded by a low, earthen, arc-shaped dike on the east, and a taxiway and aircraft runway ramp on the west. The retention pond was used starting as early as 1980 and is no longer in active use to manage surface water runoff originating from the southern portion of OU6, preventing direct flow onto Rogers Dry Lake. Suspected contaminants included oil, lubricants, and solvents; waste oil that may have been sprayed to control dust; chromium in cooling tower blowdown wastewater; and alcohol-based fuel and hydrogen peroxide oxidizer from jettison valve testing and tank purging operations.

Site N7

Site N7, Building 4827 Former Drum Storage Areas, is located south of Building 4827. The storage areas where spills may have originated were reportedly used for storage of drummed hazardous materials and wastes such as paints, paint thinners, and POL, as further discussed in the groundwater site discussion in Section 2.2.2.1.

AOC N14

AOC N14, Building 4855 Fuel Farm, was designed to serve as a storage area for Space Shuttle neutralized fuels and oxidizers. The Fuel Farm has been in operation since 1982. The suspected contaminants at this site included rocket fuels.

2.2.3 PREVIOUS SITE ACTIVITIES

2.2.3.1 Remedial Investigations and Monitoring

RI activities were performed at Sites N1, N2, N3, N4, and N7, and AOC N14 from 1987 through 1998. These activities included soil gas sampling, soil sampling, well installation, groundwater sampling, packer testing, pump testing, core sampling, fracture analysis, three-dimensional seismic reflection surveying, borehole video logging, and land surveying. Groundwater monitoring has been performed at the sites since 1992, and the current groundwater monitoring program began in 1996. Additionally, in 1991, a groundwater recovery trench was installed at Site N3, and fuel-contaminated groundwater was extracted from the trench and treated from 1992 to 1997. Details of contaminant distribution are provided in Section 2.5.

2.2.3.2 Pilot Studies

In 1997, pilot studies of vacuum-enhanced recovery and air sparge (AS)/soil vapor extraction (SVE) systems were performed at Sites N2, N3, and N7 to collect site-specific engineering data necessary for the selection of an effective extraction technology and to design cost-effective long-term treatment systems for the sites. Based upon the results of those studies, a vacuum-enhanced recovery treatability study (TS) was recommended at Sites N3 and N7, and a vacuum-enhanced recovery with sparging TS was recommended at Site N2.

2.2.3.3 Treatability Studies

Site N2

A TS was performed in order to assess the long-term viability of the AS/SVE technique in treating the trichloroethene (TCE) groundwater plume at Site N2. The TS was initiated in November 1998 and terminated in June 1999 with an interruption in operation from December 1998 to February 1999 due to mechanical difficulties. Laboratory analytical results for soil-vapor samples collected from the influent vapor stream indicated that TCE concentrations declined from 4,800 parts per billion volume per volume (ppb v/v) (the highest concentration detected during the study) to less than 10 ppb v/v. These results indicated that minimal contaminant quantities were recovered during the final 2 weeks of the study, and the cost to maintain the AS/SVE system exceeded the benefit. The TS was terminated in

June 1999 after approximately 2.43 pounds (lbs) of volatile organic compounds (VOCs) were removed from the soil vapor.

Site N3

Vacuum-Enhanced Recovery: From October 1998 to June 2001, a TS was performed to assess the long-term viability of the vacuum-enhanced recovery technique in treating the VOC (primarily TCE) and petroleum hydrocarbon contamination at Site N3. Approximately 1,071 lbs of primary contaminants (including 968 lbs of total petroleum hydrocarbons as gasoline) were removed from soil vapor and 59 lbs of contaminants (including 29 lbs of TCE) were removed from groundwater. Declining removal rates and stable and/or increasing contaminant concentrations in area wells resulted in the termination of the vacuum-enhanced recovery TS.

Chemical Oxidation: An *in situ* chemical oxidation TS was conducted at Site N3 from June to November 2002 using a Fenton-based reagent (hydrogen peroxide and chelated iron) and from March to June 2003 using persulfate and Fenton-based reagent. The TS purpose was to evaluate the effectiveness of persulfate and modified Fenton-based reagent to oxidize groundwater contamination *in situ*. The TS data indicated that VOC concentrations were reduced in some injection wells and monitoring wells.

Site N7

Vacuum-Enhanced Recovery: From October 1998 to April 1999, a TS was performed to assess the long-term viability of the vacuum-enhanced recovery technique in treating the TCE groundwater plume. Approximately 8.0 lbs of primary contaminants (including 6.4 lbs of TCE) were removed from soil vapor and 0.7 lb of contaminants (including 0.4 lb of TCE) was removed from groundwater. Although the TS data indicated a downward trend in primary contaminant concentrations in both soil vapor and groundwater, the success of vacuum-enhanced recovery was deemed temporary. The post-TS groundwater monitoring data revealed groundwater contaminant concentrations rebounded following the completion of the TS.

Chemical Oxidation: In August 2000, an *in situ* chemical oxidation TS was conducted at Site N7 using potassium permanganate to destroy groundwater contaminants *in situ*, determine the injection area

of influence, optimize bedrock injection methods, monitor permanganate persistence, and evaluate groundwater quality effects. Monitoring results indicated a horizontal radius of influence between 30 and 55 feet, and analytical results of groundwater samples collected periodically for 60 days following treatment indicated TCE and *cis*-1,2-dichloroethene concentrations were below detection limits (from pre-injection maximum concentrations of 6,500 and 790 micrograms per liter [µg/L], respectively). The success of this treatability study forms much of the basis for the remedy selection.

2.3 COMMUNITY PARTICIPATION

The OU6 RI was completed in 2000 (Earth Tech, 2000). The OU6 FS (Earth Tech, 2004) and OU6 Proposed Plan (PP) (Earth Tech, 2005) were completed and added to the Administrative Record in August 2004 and April 2005, respectively. The Administrative Record file is maintained at the 95th Air Base Wing, Environmental Management Division, 5 East Popson Avenue, Building 2650A, Edwards AFB, California, 93524.

The Edwards AFB Restoration Advisory Board (RAB) is a voluntary group meeting quarterly to facilitate the exchange of information and concerns between on-base and off-base communities, federal and state regulators, and Edwards AFB ERP managers. An overview of the PP (Earth Tech, 2005) was presented at the RAB meeting held on 17 February 2005 in Rosamond, California.

The notice of the availability of the remedial investigation/feasibility study was published in the *Antelope Valley Press*, *Desert Wings*, and *Mojave Desert News* in April 2005. A public comment period was held from 1 April to 1 June 2005. Public meetings were held on 27 April and 2 May 2005 to present the PP to a broader community audience than those that had already been involved at OU6. At the 27 April 2005 meeting held in California City, representatives from Edwards AFB, USEPA, California DTSC, and CRWQCB answered questions from the community about problems at OU6 and the proposed remedial alternatives. The 2 May 2005 meeting was held at NASA DFRC for Base and NASA DFRC workers. Few NASA DFRC and Base workers attended the 2 May 2005 meeting, and no questions regarding the proposed remedial action were received; therefore, only the 27 April 2005 public meeting was transcribed. The transcript is available in the Administrative Record file for OU6. Edwards AFB's response to the public comments received during this public comment period are included in the Responsiveness Summary (Part 3), which is a part of this ROD.

2.4 SCOPE AND ROLE OF OPERABLE UNIT OR RESPONSE ACTION

OU6 is one of nine operable units designated on Edwards AFB to group sites with similar site operations, or conditions and contaminants. OU6 is comprised of 838 acres that NASA DFRC has leased from the Air Force since 1946. The remedial action at OU6 is not dependent on the implementation of response actions at any other operable unit at Edwards AFB. OU6 is bordered to the north by OU5/10, to the east by Rogers Dry Lake, to the south by OU1, and to the west by OU8. Of the adjacent OUs, OU8 has the most hydrogeologic influence over OU6, due to the easterly groundwater flow direction in the vicinity of OU6. A groundwater extraction and treatment system has been operating near the OU8/OU6 boundary since October 2001 to hydraulically contain a TCE plume emanating from an OU8 source area (Site 25). The most recent groundwater sampling data show that the OU6 and OU8 plumes have not commingled. Though the extraction system has created a depression in the potentiometric surface along the OU8/OU6 boundary, recent groundwater elevation measurements indicate that the overall OU6 groundwater flow direction is still to the east toward Rogers Dry Lake.

CERCLA remedial activities at OU6, the subject of this ROD, focus on groundwater at Sites N2, N3, and N7. The results of RI activities and groundwater monitoring indicated that contaminants were detected in groundwater. Ingestion of water extracted from the aquifer poses potential risk to human health because USEPA's acceptable risk range is exceeded and concentrations of contaminants are greater than MCLs. Groundwater at OU6 is not currently used for drinking water, thus, potential risks associated with ingestion of COCs in groundwater are reduced by the lack of complete exposure pathways. The Air Force will implement the selected remedy using CERCLA remedial authorities, and the remedy will also meet any RCRA corrective action requirements that may be applicable. This ROD is a final remedy decision for groundwater in OU6.

2.5 OPERABLE UNIT 6 CHARACTERISTICS

2.5.1 CONCEPTUAL SITE MODEL AND FATE AND TRANSPORT

The subsurface contaminants of concern at Sites N2, N3, and N7 are VOCs, primarily TCE, in groundwater. Sources for the groundwater contamination included historical disposal and storage of

VOCs. Leaking USTs are the primary source of aromatic hydrocarbon contamination. Site-specific representations of contaminant sources and potential exposure pathways are presented on Figures 2-6, 2-7, and 2-8 for Sites N2, N3, and N7, respectively. Soil-only sites (Sites N1 and N4 and AOC N14) were suspected to have soil contamination from historic spills, disposal and waste handling practices; however, concentrations in the soils were found to be within USEPA's acceptable risk range as discussed in more detail in Section 2.7.

A groundwater model was developed to predict the groundwater flow regime at OU6 from the year 2002 to the year 2125 (approximately 125 years) assuming no remedial action, 2003 groundwater flow and transport conditions, and 2003 groundwater plume concentrations. The FEMWATER model (a three-dimensional, finite-element, groundwater flow and transport model) in *Groundwater Modeling System* software was utilized. The model indicated that without treatment the plume is persistent at levels above regulatory limits to the end of the 125-year simulation. Although the groundwater model results predicted that the TCE groundwater plume at OU6 would move at a relatively slow rate and that the leading edge should be moving at approximately 3 feet per year, groundwater monitoring since 1992 documents that the groundwater plume is not moving. The observed plume stability may indicate that plume migration has reached a steady state with dilution and dispersion at the leading edge; however, modeling results suggest that the plume is unlikely to attenuate naturally under the influence of these mechanisms. Empirical data have provided evidence that the contaminant plume movement has stabilized.

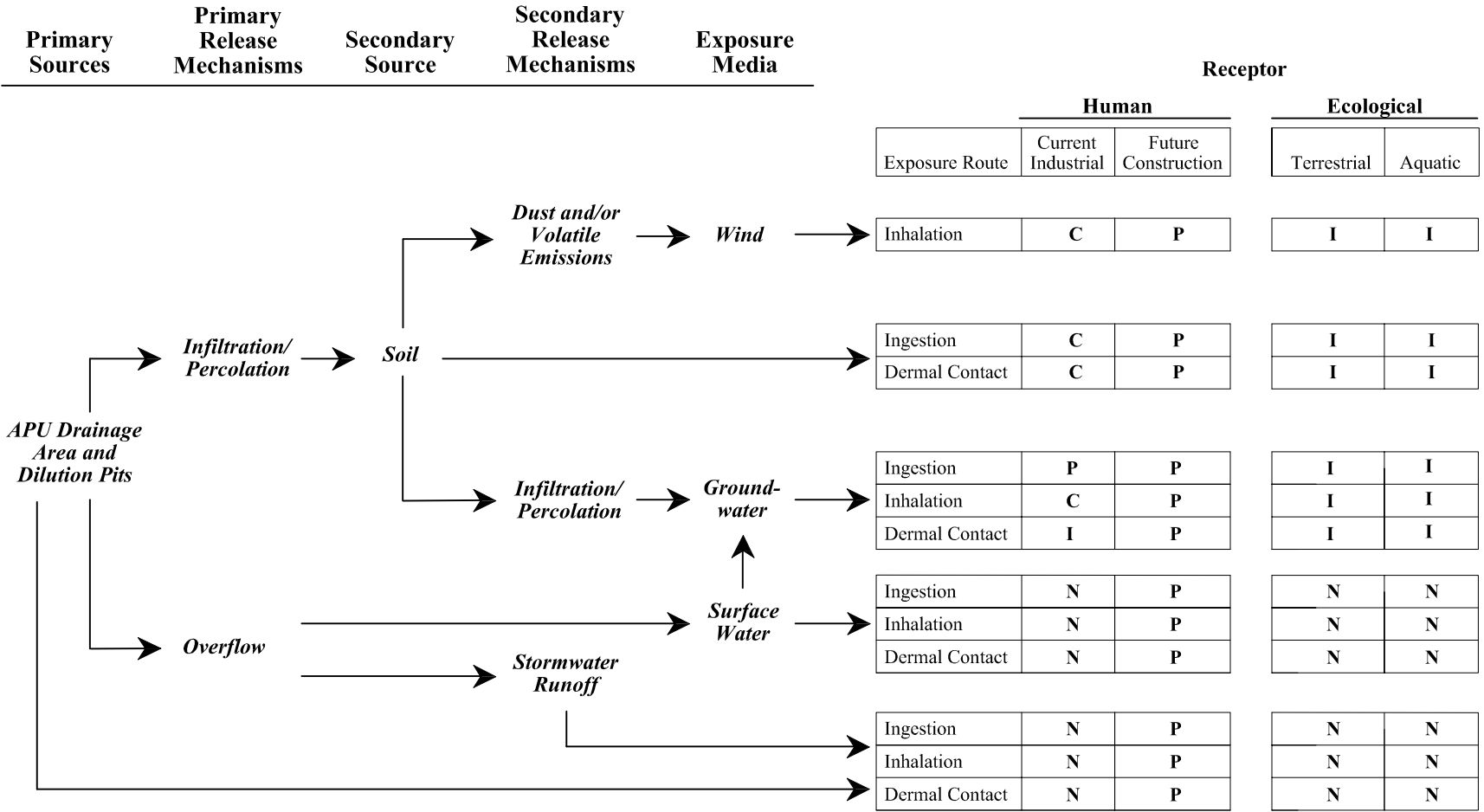
Geology

Subsurface materials underlying OU6 consist of granitic bedrock overlain by a relatively thin cover of unconsolidated alluvial and lakebed deposits, which averages 0.5 foot to 20 feet thick. The alluvial layer consists of sandy deposits derived from nearby outcrops of granitic bedrock. Hydrogeology information is presented in Section 2.5.4.3.

2.5.2 OPERABLE UNIT 6 OVERVIEW

OU6 is comprised of 838 acres at the northwestern edge of Rogers Dry Lake, in generally flat, gently sloping terrain. Surface elevations vary by approximately 30 feet between the high points on the

2-18



Notes:

APU = Auxiliary Power Unit

C = Complete pathway

I = Incomplete pathway

N = Incomplete, not applicable due to change in facility use

P = Potential pathway, currently incomplete

FINAL

Site N2
Conceptual Site Model

Date 09-2006

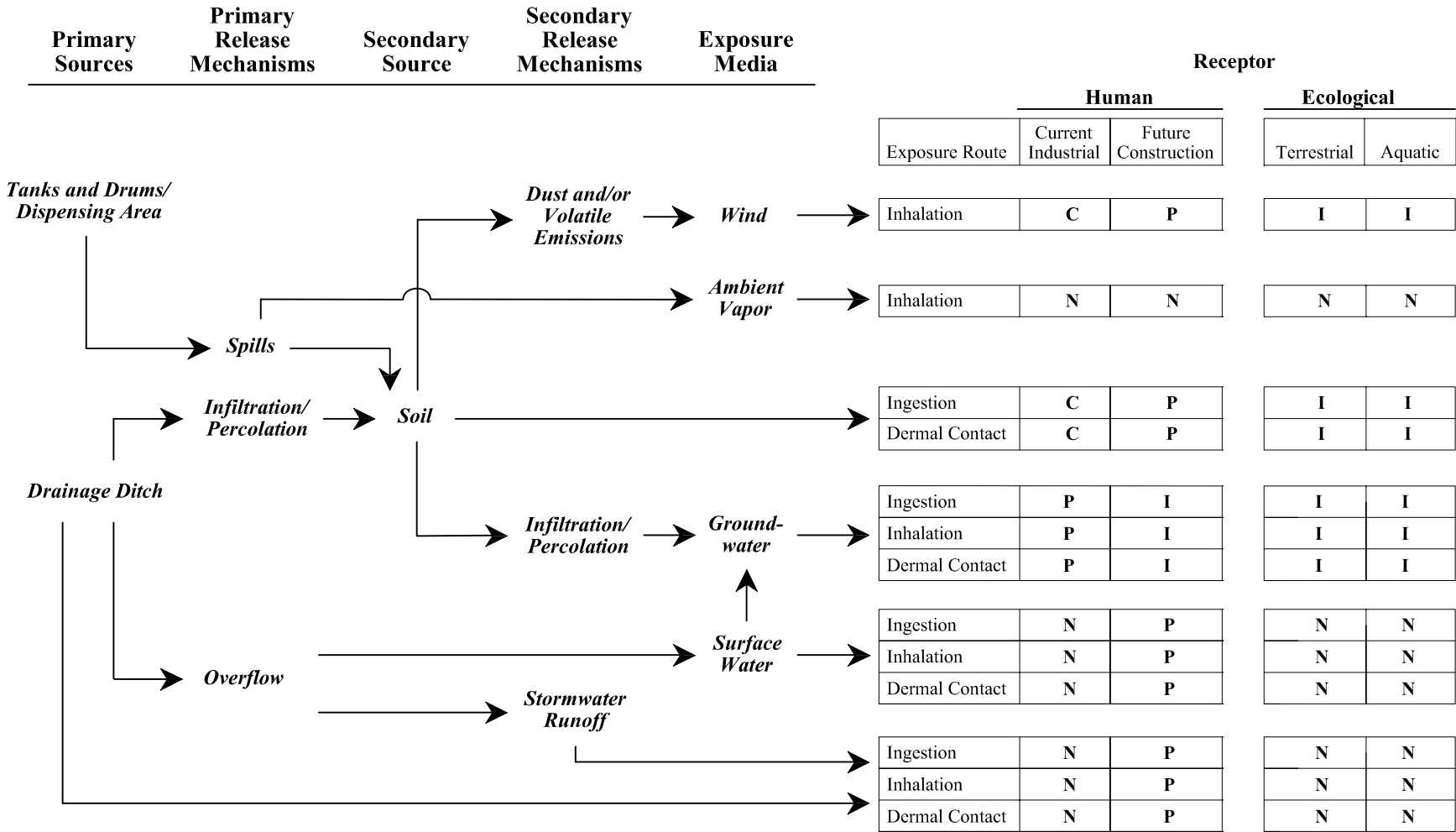
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Figure

2-6

2-19

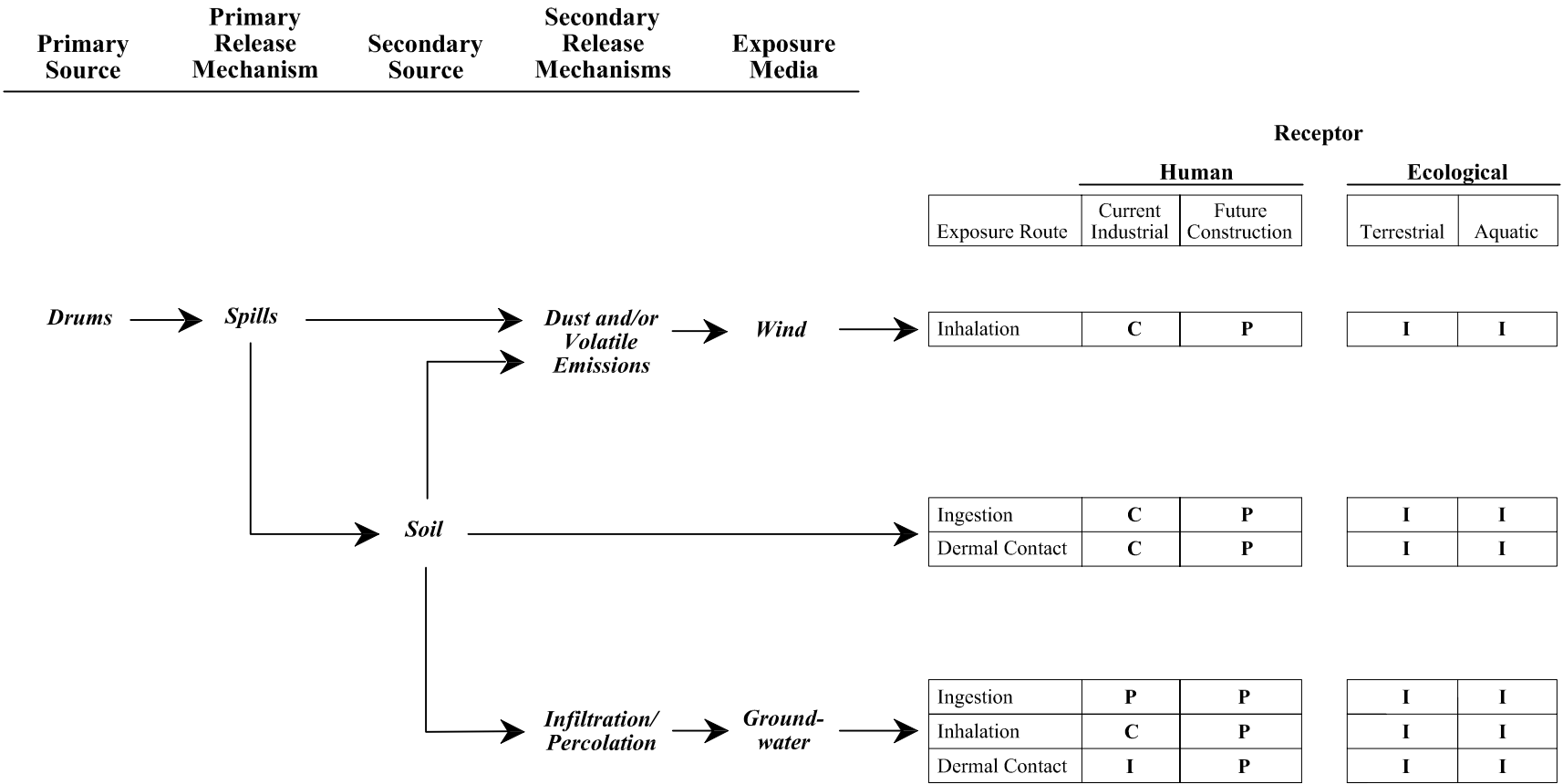


Notes:
C = Complete pathway
I = Incomplete pathway
N = Incomplete, not applicable due to change in facility use
P = Potential pathway, currently incomplete

FINAL

Site N3 Conceptual Site Model		
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2-20



Notes:

C = Complete pathway

I = Incomplete pathway

N= Incomplete, not applicable due to change in facility use

P = Potential pathway, currently incomplete

FINAL

Site N7
Conceptual Site Model

Date 09-2006

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Edwards AFB

Figure
2-8

western side of the DFRC facility and the low points along the lakebed. Most of the area situated between Forbes Avenue and Rogers Dry Lake is paved with asphalt or concrete (Figure 2-2). Drainage in the area naturally flows toward the lakebed, which floods most winters and, once flooded, often remains inundated throughout most of the winter due to low soil permeability.

Several engineered drainages and storm drains are located throughout the DFRC facility, transporting runoff to stormwater retention ponds on the edge of the lakebed. These ponds can retain water for months following particularly heavy or extended periods of rain. In the 1970s, the edge of the lakebed was altered extensively to allow the construction of a raised, concrete-paved tow-way for the Space Shuttle (The Earth Technology Corporation, 1993).

2.5.3 OPERABLE UNIT 6 FEATURES

What is now known as the DFRC facility was established in 1946, and consists of a complex of administrative, research, laboratory, service hangar, and storage buildings that support Space Shuttle, flight testing, and aeronautical research operations. The significant man-made features existing on OU6 are depicted on Figure 2-2. The northern portion of the facility is used for Space Shuttle operations and the southern portion is used for other aeronautical research and flight testing. DFRC also includes a remote radar-tracking facility located approximately 1.5 miles west of the main facility. OU6 features include: aboveground storage tanks for solvent, jet fuel, gasoline, and diesel storage and for waste storage from servicing the Space Shuttle, drum dispensing and storage areas, paint booths, stormwater retention ponds, oil/water separators, a steam plant, electrical substations, drainage ditches, and sanitary sewer lines. DFRC has implemented measures to ensure that these features are no longer sources of soil and groundwater contamination. All USTs have been removed and all hazardous materials and wastes are now managed by a pharmacy chemical management system in which all hazardous materials are stored and distributed from authorized hazardous distribution service centers (HDSC). Unused chemicals and empty containers are returned to the HDSC for storage, re-issue, disposal, and/or recycling.

No areas of archaeological interest were identified within OU6. Several buildings designated as potentially eligible for nomination to the National Register of Historic Places are present within OU6.

2.5.4 NATURE AND EXTENT OF CONTAMINATION

2.5.4.1 Operable Unit 6 Sampling

The OU6 sampling strategy included identifying source areas and delineating the extent of soil and groundwater contamination. This was accomplished for Sites N1, N2, N3, N4, and N7 and AOC N14 through the sampling of soil vapor, soil, and groundwater from 1987 through 1998. The sampling activities and other remedial activities are summarized in the FS (Earth Tech, 2004).

2.5.4.2 Contaminant Origins

The primary groundwater contamination source at Site N2 was VOC disposal into the APU Drainage Area or the adjacent Dilution Pits. The primary groundwater contamination sources at Site N3 were TCE spills at the Drum Dispensing Area and benzene, toluene, ethylbenzene, and xylene (aromatic hydrocarbons) from fuel releases from leaking USTs. The primary groundwater contamination source at Site N7 was TCE spills associated with the Drum Storage Areas and/or the Paint Shop. The groundwater contaminants at all three sites have commingled into a single plume. Contaminant origins for soil sites are discussed in Section 2.2.2.2.

2.5.4.3 Groundwater

Groundwater at OU6 occurs in a semiconfined fractured granitic bedrock medium, with the groundwater generally flowing toward the east/southeast toward the fault boundary of the regional drinking water aquifer more than 1 mile away (Leighton and Phillips, 2003). The saturated zone at OU6 lies almost entirely within the fractures in the granitic bedrock. Groundwater occurs between approximately 5 feet below ground surface (bgs) along the east side of OU6 to approximately 30 feet bgs along the west side of OU6. Groundwater elevations for wells located throughout OU6 define a water table sloping toward Rogers Dry Lake, with a horizontal groundwater velocity of approximately 42 feet per year. Vertical contaminant migration is limited due to less bedrock fractures occurring with depth. No evidence of a vadose zone contaminant source or nonaqueous phase liquids (NAPLs) was identified. Groundwater monitoring results over the past 10 years indicate that the single, commingled plume has reached steady-state conditions - the rate of advance approximately equals the rate of attenuation; thus, no further migration of groundwater contaminants is anticipated. Groundwater does not discharge to surface water.

In 2003, 17 organic constituents (including carcinogenic and noncarcinogenic chemicals) were detected in groundwater at concentrations exceeding MCLs. In 2004, 14 organic constituents were detected in groundwater at concentrations exceeding MCLs. The highest contaminant concentrations detected during the 2003/2004 sampling events are presented in Table 2-2. Of the compounds detected, benzene is a known carcinogen and suspected carcinogens include TCE, carbon tetrachloride, and 1,2-dichloroethene. Probable carcinogens include chloroform and 1,2-dibromoethane (ethylene dibromide).

The volume of TCE dissolved in groundwater was estimated based on concentration contours derived from the 2004 groundwater monitoring event as shown on Figure 2-9. Assuming an effective bulk rock porosity of 0.30 (Earth Tech, 2003b), an even vertical distribution, and a 90-foot contaminated aquifer thickness, the volume of dissolved TCE was estimated to be approximately 40 gallons. Additionally, based upon 2004 groundwater monitoring results, the TCE plume encompasses approximately 50 acres. All other VOCs exceeding MCLs are commingled within the TCE plume. The estimated volume of benzene is 0.25 gallon.

Inorganic contaminant concentrations have generally been below background values, with sporadic exceedances.

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

DFRC is NASA's primary flight research center. Current research at DFRC includes aeronautical and control systems concepts validation, atmospheric flight testing, and earth science experiments. Current research facilities include: the Flight Loads Laboratory, the Walter C. Williams Research Aircraft Integration Facility, and the Western Aeronautical Test Range. Land uses surrounding DFRC are industrial in nature and support aeronautical flight testing.

The Base GP (Higginbotham/Briggs & Associates [HB&A], 2001) specifies that DFRC will continue to be used for industrial purposes, and no residential uses, including day care facilities or other uses that would result in higher exposure amounts beyond worker exposures, of any portion of OU6 are anticipated as the Air Force will continue to occupy the Base indefinitely. Table 2-2 of the *Water Quality Control Plan for the Lahontan Region* (Basin Plan) designates the

TABLE 2-2. SUMMARY OF MCL EXCEEDANCES

Potential Chemical of Concern	Highest Detected Concentration (µg/L)	MCL (µg/L)
	2003/2004	
1,1,2,2-tetrachloroethane	430	1
1,1,2-trichloroethane	36	5
1,1-dichloroethane	100	5
1,2-dibromoethane (ethylene dibromide)	160	0.05
1,2-dichloroethane	170	0.5
<i>cis</i> -1,2-dichloroethene	1,300	6
<i>trans</i> -1,2-dichloroethene	16	10
1,2-dichloropropane	55	5
benzene	13,000	1
carbon tetrachloride	2,600	0.5
chloroform	2,300	80
ethylbenzene	1,500	300
methylene chloride	210	5
toluene	29,000	150
trichloroethene (TCE)	13,000	5
vinyl chloride	200	0.5
total xylenes	8,800	1,750

Notes:

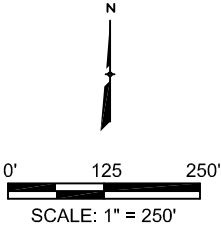
µg/L = micrograms per liter

MCL = maximum contaminant level (California Department of Health Services [DHS], 2003)



EXPLANATION

- APPROXIMATE TRICHLOROETHENE PLUME EXTENT (5 MICROGRAMS PER LITER)
- APPROXIMATE BENZENE PLUME EXTENT (1 MICROGRAMS PER LITER)
- APPROXIMATE EXTENT COMMINGLED TRICHLOROETHENE AND BENZENE PLUMES



Approximate Extent of TCE and Benzene in Groundwater
April/May 2004

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following beneficial uses for groundwater in the Antelope Valley hydrologic basin, which includes the groundwater at OU6: municipal, agricultural, industrial, and freshwater replenishment (CRWQCB, 1995).

However, there are no current or near future uses of groundwater for drinking water supply at OU6. Groundwater at OU6 is not used currently for any purposes.

Surface water bodies at OU6 consist of man-made stormwater retention and the intermittent filling of Rogers Dry Lake during the winters. OU6 stormwater drains to the lakebed via surface runoff, engineered drainages, and storm drains.

2.7 SUMMARY OF SITE RISKS

The remedial action selected in this ROD is necessary to address COC concentrations in groundwater that exceed MCLs and to restore groundwater quality to that appropriate for beneficial uses. During OU6 RI activities, an HHRA and an ecological risk assessment were performed and are included in the Administrative Record. The risk assessment approaches are described in the following sections.

2.7.1 HUMAN HEALTH RISK CHARACTERIZATION

The HHRA was performed to summarize the potential risk to human health posed by chemicals that were released into the environment. The assessment was conducted using the procedures described in the *Basewide Human Health Risk Assessment Work Plan* (Earth Tech, 2001). Details of the assessment are presented in the *Human Health Risk Assessment, NASA Dryden, Operable Unit 6* (Earth Tech, 2003a). Six OU6 sites (N1, N2, N3, N4, N7, and N14) were evaluated in the HHRA as part of the CERCLA process.

To manage risks to human health, the USEPA has developed the following risk ranges: a cancer risk of greater than 1×10^{-4} is unacceptable; from 1×10^{-4} to 1×10^{-6} is considered generally acceptable when site-specific circumstances allow; and less than 1×10^{-6} is considered acceptable. A noncancer hazard index of less than "1" is considered acceptable. It should be noted that a hazard index of greater than 1 does not necessarily mean that an actual adverse health effect will develop, but rather raises a concern of an increased potential for an adverse effect.

The risk assessment process consisted of two main steps. The first step was a preliminary, screening-level assessment. The screening-level assessment used all the chemicals detected at OU6 that were determined to be present at concentrations in excess of their naturally occurring levels. The maximum concentration of each of these chemicals was then individually compared to their USEPA preliminary remediation goals (PRGs). PRGs are risk-based concentrations developed by the USEPA for site screening purposes that are protective of human health under residential and industrial exposure scenarios. Because the PRGs for each scenario consider all potential pathways to be complete (ingestion and dermal contact with soil, and inhalation of fugitive dust and ambient air), and because the initial step of the HHRA uses the maximum concentration of each detected chemical, this preliminary assessment is considered screening-level. Although the PRGs include the risk associated with various direct and indirect exposures, they do not include the potential for volatilization from soil or groundwater into indoor air spaces. Therefore, in addition to the PRG-derived risks, potential indoor air risks were estimated for the industrial exposure scenario using the approach described by Johnson and Ettinger (Johnson and Ettinger, 1991) and maximum detected soil, groundwater, or soil gas concentrations to estimate VOC concentrations in indoor air.

The second step in the risk assessment process involved a more detailed risk evaluation. This step was used in cases where the preliminary assessment results for one or more potential exposure pathways identified in the conceptual site model (e.g., dermal contact with impacted soil and/or groundwater, ingestion of impacted soil and/or groundwater, and/or inhalation of fugitive dust and ambient air) exceeded levels designated in CERCLA to represent a significant health risk (e.g., a cancer risk in excess of 1×10^{-6} or a noncancer hazard index in excess of 1).

The detailed assessment used site-specific values for parameters such as representative chemical concentrations or exposure assumptions based on a number of factors including, but not limited to, current and future land use, the location of buildings, soil type, and depth to groundwater. In addition, to better represent concentrations to which receptors at OU6 might encounter, more site-specific exposure point chemical concentrations were sometimes used in either soil or groundwater, rather than the maximum concentrations used for the preliminary assessments.

When estimating potential cancer risks and noncancer hazards in the detailed assessment, toxicity criteria were derived from a hierarchy of sources that included the California Environmental Protection

Agency Office of Environmental Health Hazard Assessment; USEPA Integrated Risk Information System; and USEPA Region 9 PRGs (USEPA, 2000) that include criteria from a variety of other federal sources. When a chemical was listed in more than one of these sources, the most health-protective value was used.

Residential use scenarios were considered in all OU6 risk assessments as part of the PRG-based residential risk screening, during the first step. However, OU6 is an exclusively industrial use area, and both the Base GP and NASA DFRC MP state that OU6 will only be used for industrial purposes in the foreseeable future. Therefore, the detailed assessments presented in the second step of the HHRA did not include more detailed consideration of residential use.

A supplemental assessment was performed in 2006 to evaluate the potential residential risk from the soils at Sites N1, N2, N3, N4, and N7 (the supplemental assessment was not conducted for AOC N14 because the cancer and noncancer risks attributed to the site were less than the CERCLA risk levels) under more realistic exposure conditions. To obtain concentrations of the risk drivers for this scenario that better represent levels that future residential receptors might be exposed to, the chemical data in the original assessment were used to calculate the 95 percent upper confidence limit (95% UCL). The USEPA-recommended software ProUCL was used for this purpose. As described below, the results of this assessment led to a No Action decision for soils at Sites N1, N2, N3, N4, and N7. The soil at AOC N14 was selected for No Action because the cancer and noncancer risks attributed to the site were less than the acceptable CERCLA risk levels.

2.7.1.1 Soil

Based on the results of the HHRA, the PERA, and supplemental risk assessments, Sites N1, N2, N3, N4, and N7, and AOC N14 were recommended for No Action For Soil, and this recommendation is selected here in this ROD.

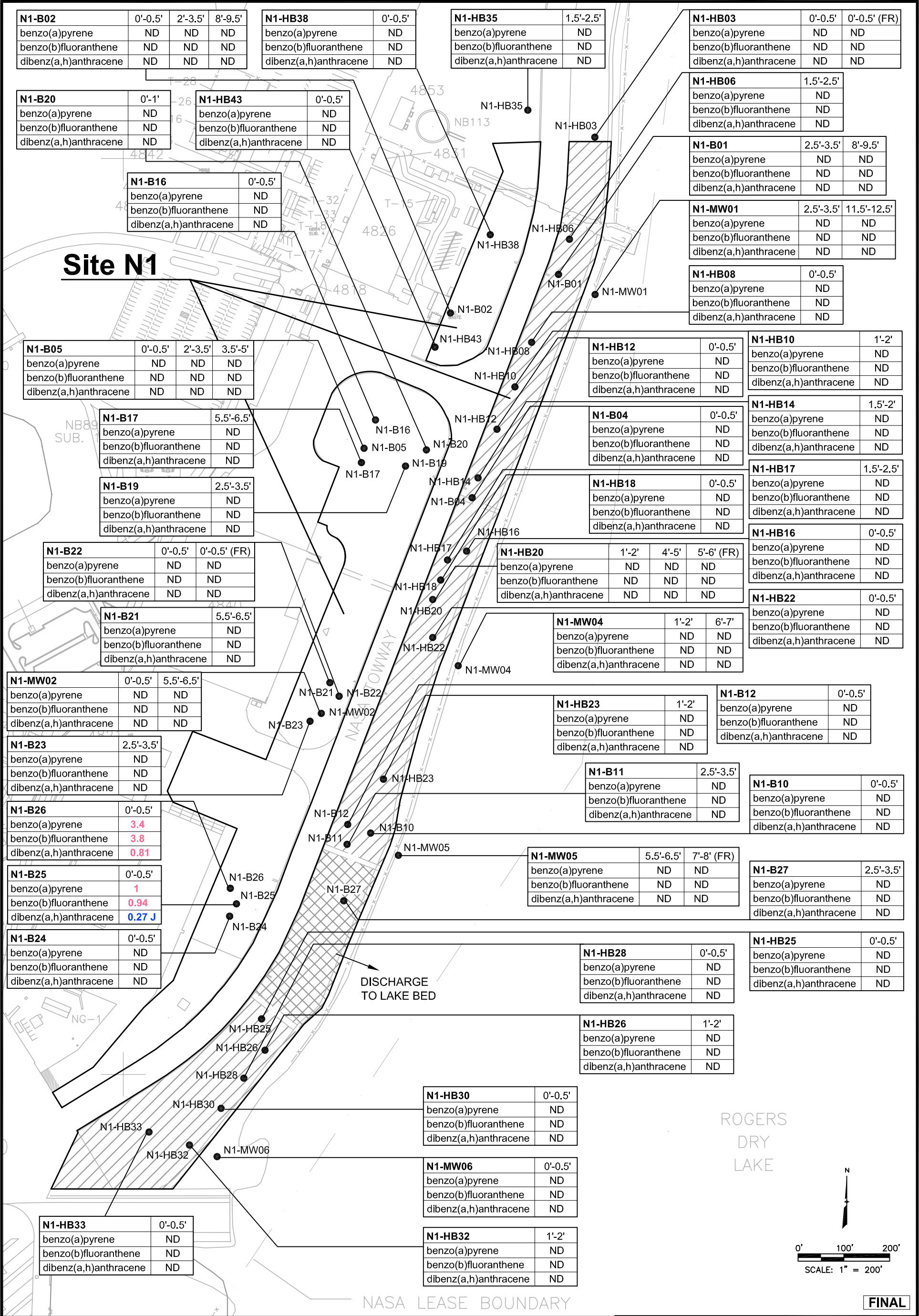
The risk assessment process, documented in the HHRA (described more fully above), consisted of two main steps. The first step was a preliminary, screening-level assessment. The screening-level assessment used all the chemicals detected at the six sites that were determined to be present at concentrations in excess of their naturally occurring levels. The maximum concentration of each of these chemicals was then individually compared to its respective USEPA Region 9 PRGs (USEPA,

2000). The second step in the risk assessment process involved a more detailed risk evaluation. This step was used in cases where the preliminary assessment results for one or more potential exposure pathways exceeded CERCLA risk levels to represent a significant health risk. As a result of this two-step process, risk drivers (chemicals in the soil whose calculated cancer risk exceeded 1×10^{-6} or noncancer hazard risk exceeded 1) for the residential scenario were identified for Sites N1, N2, N3, N4, and N7 (no contamination was found at the sixth site, AOC N14). Common cancer risk drivers for the OU6 sites are polycyclic aromatic hydrocarbons (PAHs). The common noncancer risk drivers are inorganic chemicals that include cadmium, hexavalent chromium, iron, and thallium. The residential assessments in the HHRA were conducted using the maximum detected concentrations of every chemical detected in site soil. To obtain concentrations of risk drivers that better represent levels that future residential receptors might be exposed to, the chemical data for risk drivers identified in the HHRA were used to calculate the 95% UCL of the mean. The USEPA-recommended computer program ProUCL was used to calculate the 95% UCL for this supplemental assessment.

Site N1

The HHRA identified several metals and PAHs as soil risk drivers. In the supplemental risk assessment, the 95% UCLs for these chemicals were calculated, and the statistical mean concentrations were used to recalculate the total cancer and noncancer risks for the residential scenario. The calculated cancer risk for Site N1 is 1.99×10^{-5} , and the noncancer hazard index is 3.10.

The calculated cancer risk of 1.99×10^{-5} falls within the generally acceptable range and is due primarily to the presence of PAH compounds that were detected in 2 of 57 soil samples, or 3.5 percent of samples, a frequency of detection that falls below the usual 5 percent exclusion threshold and indicates that these chemicals are not representative of the site as a whole. The samples were collected from 44 sample locations that ranged in depth from 0.5 foot bgs to 12.0 feet bgs (Figure 2-10). The two samples in which PAHs were detected were collected from two different sample locations at a depth of 0.5 foot bgs near asphalt pavement. PAHs are a common component of asphalt and, given the shallowness of the soil samples in which the PAHs were detected, it is likely that the soil samples contained some asphalt. Therefore, the PAHs do not appear to be a part of the original CERCLA release. Minor contributors to the cancer risk include cadmium and hexavalent chromium.



EXPLANATION

- SAMPLING POINT
- FR = FIELD REPLICATE
- ND = NOT DETECTED

SAMPLES COLLECTED 9/95 TO 11/95 AND 3/97

0.27 J RESULT IS DETECTED BELOW THE REPORTING LIMIT.

3.4 RESULT IS DETECTED ABOVE THE REPORTING LIMIT.

ALL RESULTS ARE IN MILLIGRAMS PER KILOGRAM (mg/kg)

PORTION OF CURRENT POND TO BE FILLED WITH SOIL AS PART OF POND REALIGNMENT

FUTURE POND AREA

Site N1

Northern Retention Pond

Chemicals of Concern Detected in Soil

Date 09-2006

Project No.
54212

Operable Unit 6
Record of Decision
Edwards AFB

Figure

2-10

The noncancer hazard index of 3.10 is due primarily to the presence of the metals: aluminum, manganese, and thallium. These metals occur naturally in site soils. A hazard index for the residential scenario of 2.90 was calculated for background concentrations (concentrations found naturally) of metals and inorganic compounds using the PRG comparison approach described for the preliminary risk assessment. The hazard index value for Site N1 of 3.10 is only a 6.9 percent increase over the background hazard index of 2.90. Major contributors to the hazard index for the background metals and inorganic compounds include aluminum, iron, and manganese. Although the risk calculation indicates that soil contaminants at the site potentially could pose a risk, the cancer risk is within the generally acceptable range, and the noncancer hazard index is close to that from background concentration levels for metals and inorganics. Therefore, No Action was recommended for Site N1 soil, and is selected here.

Site N2

The HHRA identified PAHs and several metals (hexavalent chromium, iron, organic lead, and thallium) as risk drivers. Although organic lead was initially identified as a risk driver and was detected in two of two soil samples, the validity of organic lead results are suspect for the following reasons: there are uncertainties associated with the analytical method used to detect organic lead; detected concentrations for both samples were below the analytical method reporting limit; detected concentrations exceeded the detected concentration for total lead in both samples; organic lead was detected in equipment blank samples at concentrations similar to the levels reported for the two soil samples; and organic lead was not detected in water samples from groundwater monitoring wells at the site. Because of the high uncertainty associated with the organic lead results for the two soil samples, the organic lead was eliminated from further consideration as a risk driver for Site N2.

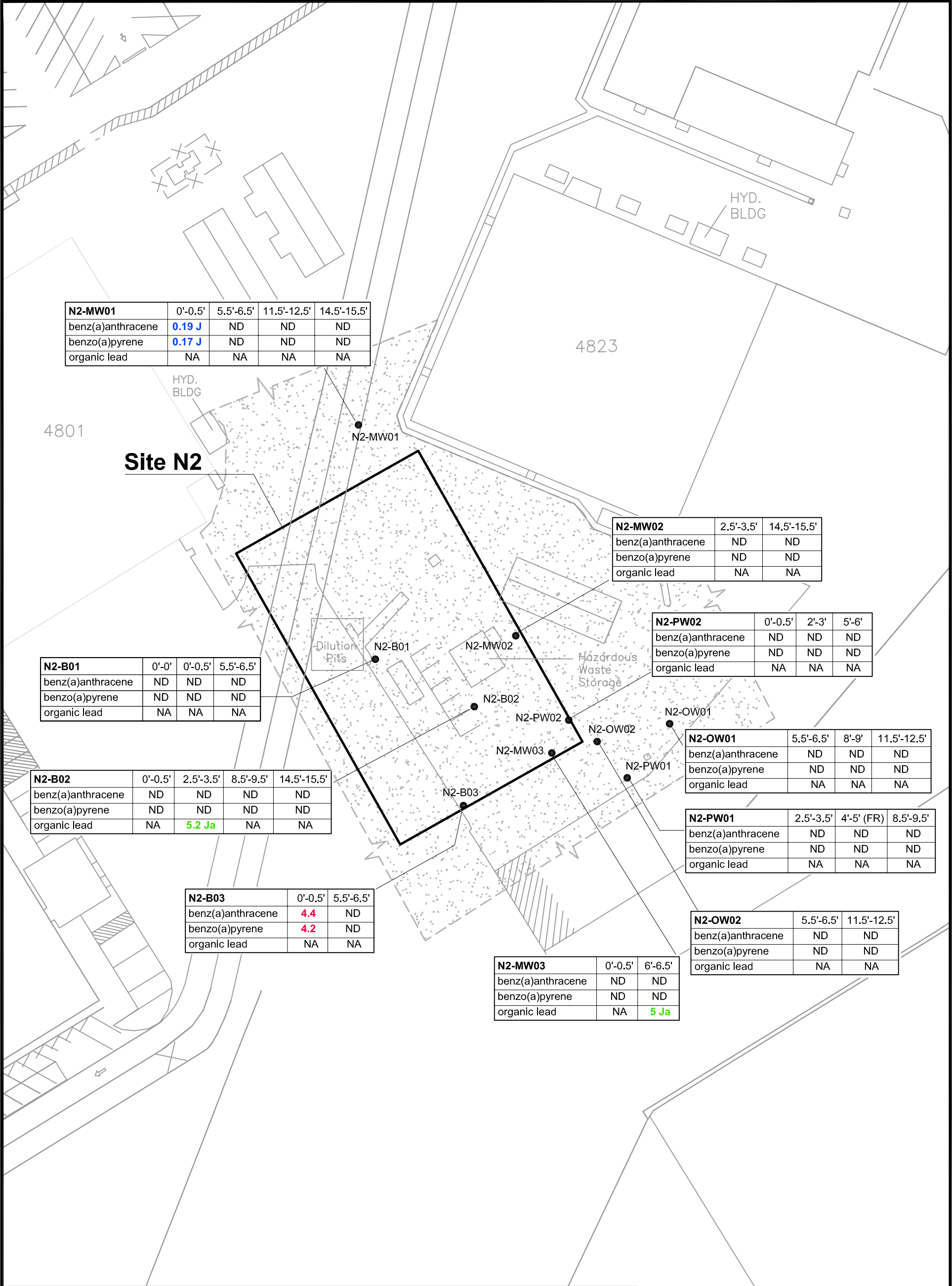
Based on the supplemental risk assessment using the 95% UCLs for the identified risk drivers (PAHs, hexavalent chromium, iron, and thallium), the calculated cancer risk for Site N2 is 2.48×10^{-5} , and the noncancer hazard index is 2.55. The calculated cancer risk falls within the generally acceptable range, and the calculated noncancer hazard index is greater than 1 but is less than the background hazard index of 2.90.

Based on the results of the HHRA, the PERA, and supplemental risk assessments, the recommended remedy for soil at Site N2 was No Action, and is selected here. This selection is warranted because the risk assessment process used is extremely conservative in nature; the calculated human health and environment risks fall within the generally acceptable range; and contaminants identified as risk drivers are likely not associated with Air Force/NASA DFRC use of the site. For example, PAHs were detected in only 2 of 28 soil samples collected at different sample locations at a depth of 0.5 foot bgs from beneath asphalt pavement (Figure 2-11). PAHs are a common component of asphalt and, given the shallowness of the soil samples in which the PAHs were detected, it is likely that the soil samples contained some asphalt. Therefore, the PAHs do not appear to be a part of the original CERCLA release.

Site N3

The HHRA identified several metals (cadmium, iron, organic lead, and thallium), and PAHs (primarily benzo(a)pyrene) as the soil risk drivers at Site N3. Although organic lead was initially identified as a risk driver and was detected in 34 of 35 soil samples, the validity of organic lead results are suspect for the following reasons: there are uncertainties associated with the analytical method used to detect organic lead; detected concentrations for the samples were below the analytical method reporting limit; detected concentrations exceeded the detected concentration for total lead in 17 of the 34 samples; organic lead was detected in equipment blank samples at concentrations similar to the levels reported for the 34 soil samples; organic lead was detected in 1 of 4 groundwater monitoring wells (an upgradient monitoring well screened in granitic bedrock); and organic lead was detected in equipment blank samples associated with the groundwater sampling. Thus, organic lead was eliminated as a risk driver in the supplemental risk assessment.

Based on the supplemental risk assessment using the 95% UCLs for the identified risk drivers (PAHs, cadmium, iron, and thallium), the calculated cancer risk for Site N3 is 2.98×10^{-5} , and the calculated noncancer hazard index is 3.52. The calculated cancer risk falls within the generally acceptable range, and the calculated noncancer hazard index is greater than 1, but within 21 percent of the background hazard index of 2.90.



EXPLANATION

- SAMPLING POINT
- 0.19 J

RESULT IS DETECTED BELOW THE REPORTING LIMIT.
- 5.2 Ja

RESULT IS DETECTED ABOVE THE DETECTION LIMIT BUT LESS THAN THE REPORTING LIMIT. CONSIDERED QUANTITATIVELY UNCERTAIN.
- 4.4

RESULT IS DETECTED ABOVE THE REPORTING LIMIT.
- PAVED AREA
- FR

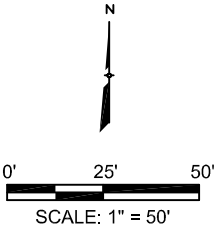
= FIELD REPLICATE
- ND

= NOT DETECTED
- NA

= NOT ANALYZED

SAMPLES COLLECTED 10/95-11/95

ALL RESULTS ARE IN MILLIGRAMS PER KILOGRAM (mg/kg)



FINAL

Site N2
Former Auxiliary Power Unit Drainage Area
Chemicals of Concern Detected in Soil

Date 09-2006	Operable Unit 6 Record of Decision Edwards AFB	Figure 2-11
Project No. 54212		

Based on the results of the HHRA, the PERA, and supplemental risk assessment, the recommended remedy for soil at Site N3 was No Action, and is selected here. This selection is warranted because the risk assessment process used is extremely conservative in nature; the calculated human health and environment risks fall within the generally acceptable range; and contaminants identified as risk drivers are likely not associated with Air Force/NASA DFRC use of the site. For example, PAHs were detected in only 9 of 45 soil samples collected at different sample locations from beneath asphalt pavement (Figure 2-12). PAHs are a common component of asphalt and, given the shallowness of the soil samples in which the PAHs were detected, it is likely that the soil samples contained some asphalt. Therefore, the PAHs do not appear to be a part of the original CERCLA release.

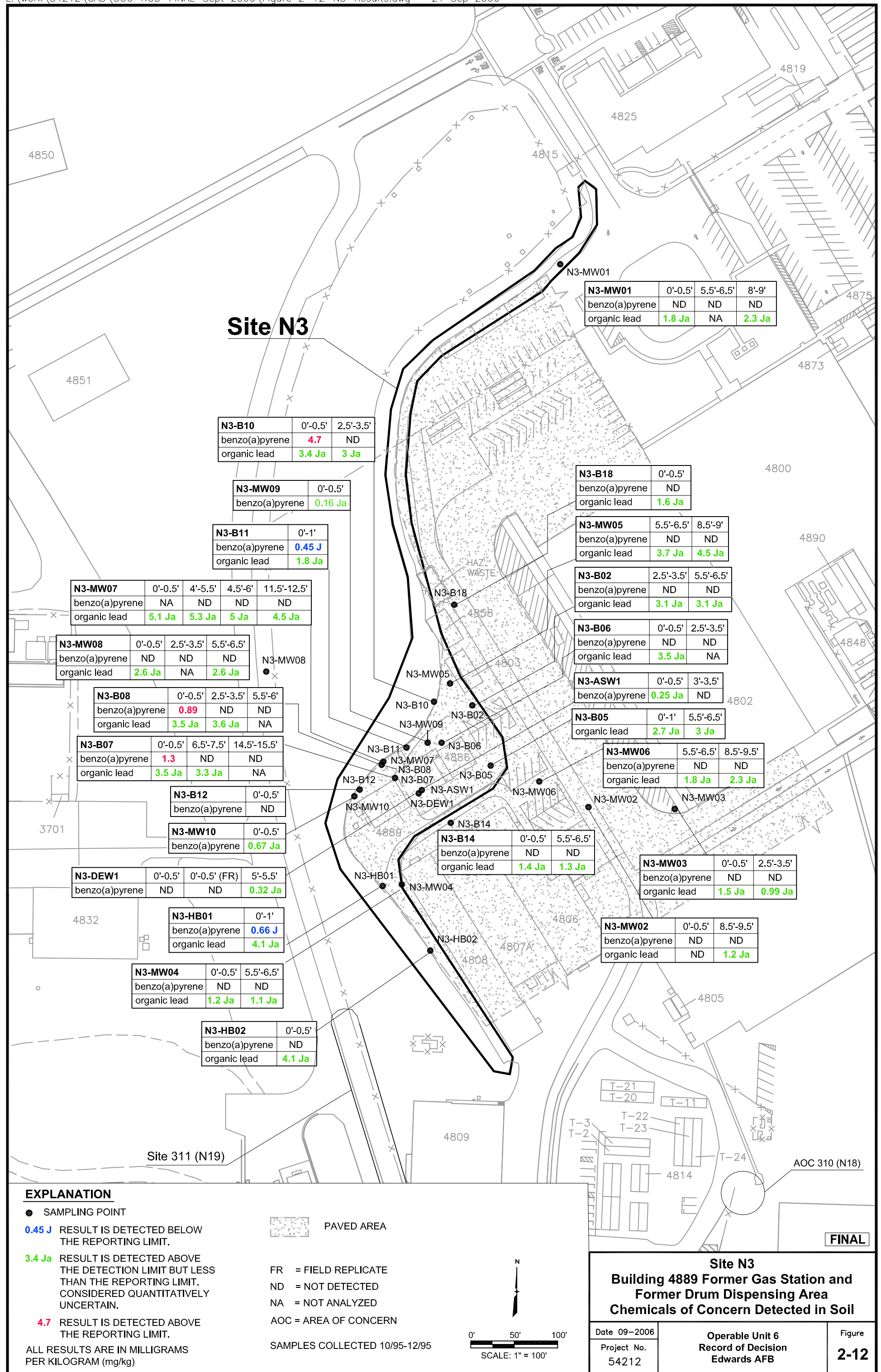
Site N4

The HHRA identified several metals (aluminum, antimony, and iron), polychlorinated biphenyls, and PAHs as the soil risk drivers. The supplemental risk assessment was performed to evaluate the health risks at the site based on the residential scenario. This assessment used the 95% UCLs to derive the statistical mean concentration of the identified soil risk drivers. The calculated cancer risk for the site is 6.39×10^{-6} and the calculated noncancer hazard index is 2.19. The calculated cancer risk is within the generally acceptable risk range, and the calculated noncancer hazard index of 2.19 is less than the background hazard index of 2.90.

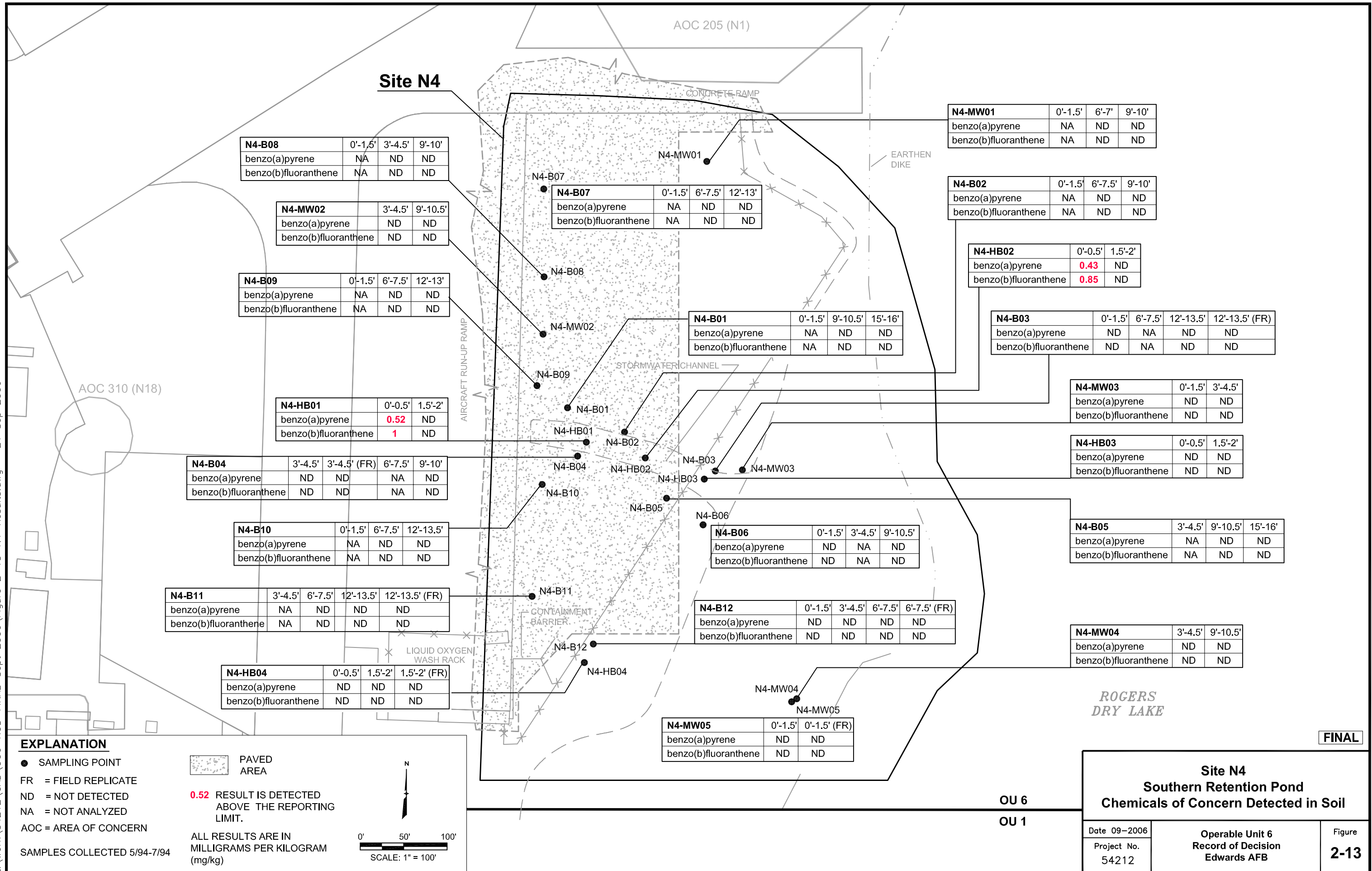
The primary cancer risk drivers from site soil are PAHs (primarily benzo(a)pyrene). This PAH was detected in 2 of 48 soil samples, or 4.2 percent, a frequency of detection that falls below the usual 5 percent exclusion threshold and indicates that these chemicals are not representative of the site as a whole. Both samples were collected from a depth of 0.0 to 0.5 foot bgs from beneath asphalt pavement (Figure 2-13). PAHs are a common component of asphalt and, given the shallowness of the soil samples in which the PAHs were detected, it is likely that the soil samples contained some asphalt. Therefore, the PAHs do not appear to be a part of the original CERCLA release.

On the basis of the calculated cancer risk falling in the acceptable range and the hazard index for Site N4 soil being below the background hazard index, No Action was recommended for Site N4 soil, and is selected here.

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Site N7

The HHRA identified PAHs (benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene) as the primary soil risk drivers. The residential hazard index was calculated to be 0.755. In the supplemental risk assessment, the 95% UCLs for primary risk drivers were calculated, and the statistical mean concentrations were used to recalculate the total cancer risk for the residential scenario. The initial results of the recalculated cancer risk indicated a total risk of 1.80×10^{-4} . These results were driven by the benzo(a)pyrene risk of 1.16×10^{-4} . However, benzo(a)pyrene, along with the other PAHs, was detected in only one of eight samples collected at the site. Thus, the 95% UCL may not be as representative a measure of site-wide benzo(a)pyrene concentrations as an average. Using the average concentration of benzo(a)pyrene, the total cancer risk is estimated at 2.08×10^{-5} . The cancer risk value falls within the generally acceptable risk range and the noncancer hazard index value, which is less than 1, is considered acceptable. Even though PAHs were identified as the site risk drivers, they were detected in only 1 of 8 samples collected to a maximum depth of 0.5 foot bgs near asphalt pavement (Figure 2-14). PAHs are a common component of asphalt and, given the shallowness of the soil samples, it is likely that the soil samples contained some asphalt. Therefore, the PAHs do not appear to be a part of the original CERCLA release.

Based on the cancer risk results falling within the acceptable range and the noncancer hazard index being below 1, No Action was recommended for Site N7 soil, and is selected here.

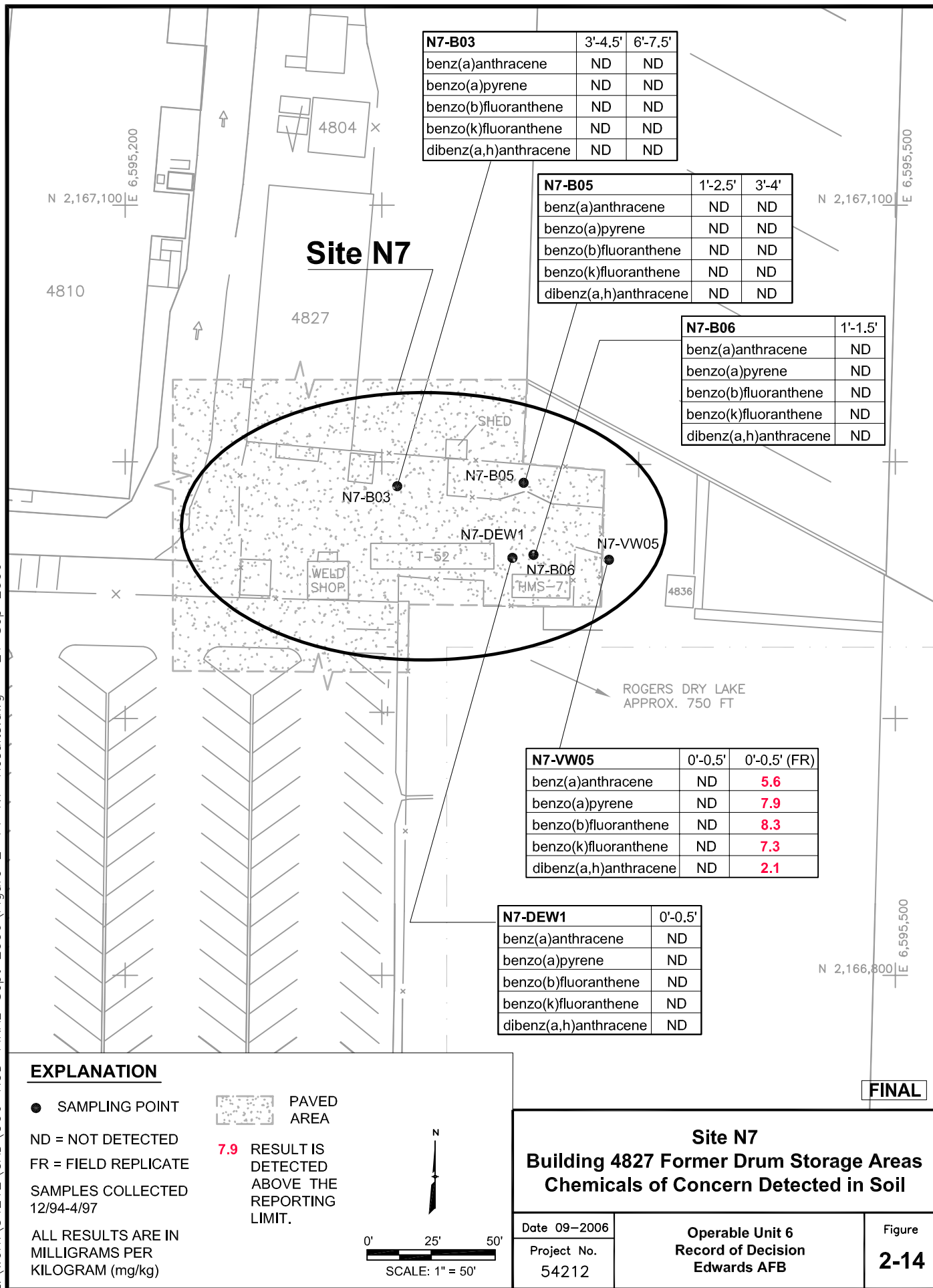
AOC N14

The HHRA documented that the residential cancer risk does not exceed 1×10^{-6} , and the noncancer risk does not exceed 1. No Action was recommended for AOC N14 soil, and is selected here.

2.7.1.2 Groundwater

The remedial action selected in this decision document addresses COCs in groundwater at OU6 as a single commingled plume associated with Sites N2, N3, and N7.

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N7-B03	3'-4.5'	6'-7.5'
benz(a)anthracene	ND	ND
benzo(a)pyrene	ND	ND
benzo(b)fluoranthene	ND	ND
benzo(k)fluoranthene	ND	ND
dibenz(a,h)anthracene	ND	ND

N7-B05	1'-2.5'	3'-4'
benz(a)anthracene	ND	ND
benzo(a)pyrene	ND	ND
benzo(b)fluoranthene	ND	ND
benzo(k)fluoranthene	ND	ND
dibenz(a,h)anthracene	ND	ND

N7-B06	1'-1.5'
benz(a)anthracene	ND
benzo(a)pyrene	ND
benzo(b)fluoranthene	ND
benzo(k)fluoranthene	ND
dibenz(a,h)anthracene	ND

N7-VW05	0'-0.5'	0'-0.5' (FR)
benz(a)anthracene	ND	5.6
benzo(a)pyrene	ND	7.9
benzo(b)fluoranthene	ND	8.3
benzo(k)fluoranthene	ND	7.3
dibenz(a,h)anthracene	ND	2.1

N7-DEW1	0'-0.5'
benz(a)anthracene	ND
benzo(a)pyrene	ND
benzo(b)fluoranthene	ND
benzo(k)fluoranthene	ND
dibenz(a,h)anthracene	ND

The potential cancer and noncancer risks associated with ingestion of groundwater under the residential exposure scenario were evaluated in the preliminary assessments for Sites N2, N3, and N7. As discussed in the HHRA, these risks were calculated assuming that site groundwater would be the sole source of water used by residential families over a 30-year period for drinking and bathing. The groundwater assessments were performed using a comparison to tap water PRGs for the residential scenario and expressing this ratio as a cancer risk or a noncancer hazard quotient. The results of these assessments indicated that total cancer risks ranged from approximately 6.3×10^{-1} to 2.7×10^{-3} , and total noncancer risks ranged from approximately 23,531 to 87.4. The risk drivers at each of these sites are listed in the HHRA, but the main chemicals included TCE, 1,2-dibromoethane, 1,2-dichloroethane, benzene, naphthalene, iron, and *cis*-1,2-dichloroethene.

Additionally, the HHRA evaluated potential risks and hazards resulting from worker exposure to groundwater. Indirect pathways (e.g., exposure to groundwater VOCs via volatilization into ambient and indoor air) could be considered complete (Earth Tech, 2003a). The potential cancer risks and noncancer hazards were assessed, and determined to be below the CERCLA risk criteria.

The HHRA also evaluated potential risks and hazards resulting from dermal and/or inhalation exposure to groundwater for the worker performing construction and excavation activities. For the purpose of these assessments, excavation depth was assumed to be as great as 12 feet bgs. Depth to groundwater is typically 12 feet bgs or deeper at Sites N2 and N3, but is less than 12 feet bgs at Site N7. Therefore, for the purpose of the assessments presented in the HHRA, it was assumed that excavation at Site N7 would result in routine direct dermal contact with groundwater. However, since groundwater is typically deeper than 12 feet bgs at Sites N2 and N3, and excavation will not always extend to 12 feet bgs, it was not reasonable to assume that excavation would typically lead to direct groundwater exposure at Sites N2 and N3. Ingestion of groundwater at Site N7 was not assumed to occur, because NASA DFRC would require such trenches to be dewatered before allowing worker entry. Exposure via inhalation of VOCs was assumed to be a complete pathway at Sites N2, N3, and N7.

The results of the assessments for the construction/excavation scenario presented in the HHRA indicated cancer and noncancer risks below the CERCLA criteria for Site N2. The estimated cancer risk for Site N3 was below 1×10^{-6} , and the noncancer results were approximately 6.1, due primarily to naphthalene and carbon tetrachloride. The potential cancer and noncancer risk results for Site N7 were

approximately 4.2×10^{-3} and 814. The results were due to TCE, 1,2,3-trichloropropane, 1,1-dichloroethene, and carbon tetrachloride via the inhalation route.

2.7.2 ECOLOGICAL RISK CHARACTERIZATION

The OU6 ecological risk assessment was conducted in three phases. The first was a pre-Scoping Ecological Risk Assessment (pre-SERA) (United States Geological Survey [USGS], 2002). The pre-SERA (USGS, 2002) gathered basic site characteristic data and screened sites for the second phase, the SERA (USGS, 2003). The SERA (USGS, 2003) results determined which sites needed to be more fully evaluated in the third phase, the PERA (Tetra Tech, 2003).

The pre-SERA (USGS, 2002) was performed to evaluate the presence and quality of habitat and the potential for off-site transport of contaminants. Criteria used for this screening evaluation included the groundwater depth, the existence (if any) of homestead wells, and evidence (if any) of off-site contaminant transport. Edwards AFB includes property that was formerly homesteaded, farms and other holdings, many of which included shallow water wells. No former homesteads or homestead wells are included in OU6. Pre-SERA results indicated that evidence of contaminant impact was present and that a full SERA (USGS, 2003) was necessary for 19 OU6 sites (USGS, 2002).

The SERA (USGS, 2003) was performed to evaluate the chemical, physical, and biological characterization of each site and the potential for complete exposure pathways to ecological receptors at 19 sites in OU6. Contaminants of ecological concern, as well as potential exposure pathways, were identified for each site, and potential fate and transport pathways were evaluated. Assessment results indicated that potential wildlife receptors were present or had access to contaminants of potential ecological concern (COPECs). The SERA (USGS, 2003) results indicated that a PERA was necessary at Sites N1 and N4 and AOC N14.

The PERA (Tetra Tech, 2003) indicated that some COPECs in soil, surface water, and groundwater may pose potential risks to some receptor groups at Site N1, and COPECs in soil and groundwater may pose potential risks to some receptor groups at Site N4. Risks calculated for COPEC concentrations at Sites N1 and N4 are of limited ecological significance, and none of the COPECs identified at AOC N14 pose a risk to receptor groups at the site. The remaining calculated risks are reduced by the existence of low quality habitat (for all receptors) due to proximity to ongoing industrial processes and related

development. Physical disturbance to the habitat quality is related to high traffic resulting from ongoing industrial processes. Additionally, no threatened or endangered plants, invertebrates, birds, reptiles, or mammals were reported at the sites. The results of the three-phase ecological risk assessment indicate there is no ecological risk.

2.8 REMEDIAL ACTION OBJECTIVES

The remedial action objectives (RAOs) and selected action were developed and presented in the FS (Earth Tech, 2004) based upon CERCLA and NCP requirements, human health and ecological risk evaluations, and ARARs. The RAOs include:

- The restoration of groundwater to its designated beneficial use as drinking water
- The prevention of exposure of human receptors to contaminated groundwater until groundwater contaminant concentrations are below MCLs

The exposure pathways that need to be prevented and/or minimized are ingestion, dermal contact, and inhalation of groundwater vapors.

2.9 DESCRIPTION OF ALTERNATIVES

2.9.1 DESCRIPTION OF REMEDY COMPONENTS

During the FS process, five remedial alternatives were developed and analyzed in detail. These alternatives, and their primary components, include:

- **Alternative 1: Land Use Controls (LUCs) (Described as Access Restrictions in the OU6 Feasibility Study [Earth Tech, 2004])**
 - Implement, monitor, maintain, enforce and report LUCs on groundwater in accordance with the Base GP and NASA DFRC MP (discussion of LUCs is provided in Section 2.12.2.1)
 - Perform 5-year reviews every 5 years until no contaminants remain above cleanup levels (MCLs)
- **Alternative 2: Groundwater Monitoring/Hydrologic Control**
 - Implement all components of Alternative 1
 - Demonstrate the effectiveness of natural attenuation at low concentration areas of the groundwater plume (Hydrologic Control) through periodic groundwater monitoring, and document reduction in contaminant levels throughout the plume

- **Alternative 3: *In Situ* Chemical Oxidation of the Entire Plume (formerly titled “Chemical Reaction”)**
 - Implement all components of Alternative 1
 - Treatment of entire plume via *in situ* chemical oxidation
- **Alternative 4: The Selected Remedy; *In Situ* Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring (formerly titled “Source Control and Hydrologic Control with Groundwater Monitoring”)**
 - Implement all components of Alternatives 1 and 2
 - Treatment of high concentration portions of the chlorinated hydrocarbon plume via *in situ* chemical oxidation
 - Treatment of high concentration portions of the aromatic hydrocarbon plume via enhanced natural attenuation (bioremediation)
- **Alternative 5: No Action**

2.9.2 COMMON ELEMENTS AND DISTINGUISHING FEATURES OF EACH ALTERNATIVE

Although groundwater at OU6 is not used, nor is anticipated to be used, for any purpose, the CRWQCB has assigned a potential drinking water designation to the groundwater. The key ARARs driving the remedial action are chemical-specific (MCLs for drinking water). Because of the unique aquifer characteristics (fractured bedrock medium), no presumptive remedies were considered to be effective and none are utilized. For those alternatives considered during the FS process, none required the management of untreated waste, the treatment of residuals, or off-site disposal.

The remedial action implementation assumptions were for cost-estimating and comparison purposes only and actual project parameters will be determined during the project design phase. For cost estimates, an assumed discount rate of 3.2 percent was applied to each alternative. Estimated costs are summarized in Section 2.12.3.1 and are provided in detail in the FS (Earth Tech, 2004).

2.9.2.1 Alternative 1

Although the alternative maintains incomplete exposure pathways, no active treatment of contaminants or monitoring occurs. Because Alternative 1 does not treat contaminants, contaminant mass is not reduced. The time to achieve MCLs in groundwater through natural processes is unknown or may not occur, and those processes are not monitored. Therefore, RAOs and ARARs may not be achieved.

Alternative 1 does not impact current or anticipated (industrial) OU6 uses. It will continue to limit access and prevent risk to human health and the environment by maintaining the current incomplete exposure pathways. No beneficial groundwater uses will be available

Capital costs for Alternative 1 were estimated to be approximately \$2,800, total operation and maintenance (O&M) costs were estimated to be approximately \$82,400, and total periodic costs were estimated to be approximately \$109,200. The total present value cost for the alternative was estimated to be \$125,600 based upon a 30-year analysis period.

2.9.2.2 Alternative 2

Although the alternative maintains incomplete exposure pathways, no active treatment of contaminants occurs. Because Alternative 2 does not treat contaminants, contaminant mass is not reduced. The time to achieve MCLs in groundwater through natural processes is unknown or may not occur; therefore, RAOs and ARARs may not be achieved. However, the contaminants are monitored.

Alternative 2 maintains the current OU6 industrial activities, does not impact current or anticipated (industrial) OU6 uses, verifies hydrologic containment of the plume through groundwater monitoring. It will continue to limit access and prevent risk to human health and the environment by maintaining the current incomplete exposure pathways. No beneficial groundwater uses will be available.

Capital costs for Alternative 2 were estimated to be approximately \$159,600, total O&M costs were estimated to be approximately \$1,540,300, and total periodic costs were estimated to be approximately \$109,200. The total present value cost for the alternative was estimated to be \$1,342,500 based upon a 30-year analysis period.

2.9.2.3 Alternative 3

Because the *in situ* chemical oxidation technology destroys contaminants, Alternative 3 can meet RAOs and chemical-specific ARARs. *In situ* chemical oxidation was employed, and exhibited effectiveness, during the TSs at OU6 and is effective long-term because contaminants are chemically altered. The timeframe is approximately 3 years of injection and processing time followed by long-term groundwater monitoring. Monitoring would consist of seven annual events. The estimated time to reach MCLs in groundwater is approximately 10 years.

Alternative 3 will continue to limit access and prevent risk to human health and the environment by maintaining the current incomplete exposure pathways. Beneficial groundwater uses will be available.

Capital costs for Alternative 3 were estimated to be approximately \$43,948,100, total O&M costs were estimated to be approximately \$28,196,900, and total periodic costs were estimated to be approximately \$1,464,800. The total present value cost for the remedial action was estimated to be \$71,458,900 based upon a 10-year analysis period.

2.9.2.4 Alternative 4

Because the *in situ* chemical oxidation technology destroys contaminants, Alternative 4 can meet chemical-specific ARARs. Injection and monitoring timeframes will be based upon conditions encountered in the field. Based on a groundwater model of the OU1 groundwater plume adjacent to the OU6 plume, occurring in the same aquifer (900 feet upgradient), and consisting of similar contaminants and contaminant levels as the OU6 plume, the time to achieve MCLs in groundwater through treatment and natural processes is conservatively 130 years (Earth Tech, 2006).

The *in situ* chemical oxidation technology employed in Alternatives 3 and 4 involves the injection of reagents directly into the subsurface to destroy organic contaminants. The primary reagent that is expected to be used, permanganate, is used to oxidize chlorinated contaminants to four harmless components: manganese dioxide, chloride ions, hydronium ions, and carbon dioxide. During the implementation of Alternatives 3 and 4, permanganate would convert naturally occurring trivalent chromium to hexavalent chromium, a carcinogen. However, the hexavalent chromium would be transitional and return to the trivalent form in groundwater once oxidation conditions degrade. Based on treatability study results, hexavalent chromium returned to the trivalent form within 5 years of introducing permanganate into OU6 groundwater.

Alternative 4 maintains the current OU6 industrial activities, does not impact current or anticipated (industrial) OU6 uses, and verifies hydrologic containment of the plume through groundwater monitoring. It will continue to limit access and prevent risk to human health and the environment by maintaining the current incomplete exposure pathways. Beneficial groundwater uses will then be available although none are anticipated.

Capital costs for Alternative 4 were estimated to be approximately \$464,300, total O&M costs were estimated to be approximately \$1,885,600, and total periodic costs were estimated to be approximately \$109,200. The total present value cost for the remedial action was estimated to be \$1,905,800 based upon a 30-year analysis period.

2.9.2.5 Alternative 5

The alternative does not meet RAOs since access is not limited and therefore exposure pathways exist for workers performing intrusive activities. Because Alternative 5 does not include any action, chemical-specific ARARs may not be met. The timeframe for natural processes to disperse contaminants to concentrations below MCLs is unknown or may not occur, and these processes are not monitored.

Alternative 5 maintains the current OU6 industrial activities and does not impact current or anticipated (industrial) OU6 uses, but does not ensure industrial uses in the long-term. The current controls to limit access and prevent risk to human health and the environment by maintaining the current incomplete exposure pathways are not assumed. No beneficial groundwater uses will be available. There are no costs associated with Alternative 5.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

During the FS process, the relative performance of the alternatives was evaluated with respect to the nine evaluation criteria to identify the advantages and disadvantages of each alternative. These criteria include:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Regulatory agency acceptance
- Community acceptance

A comparative analysis of alternatives presented in the FS (Earth Tech, 2004) is summarized in Sections 2.10.1 through 2.10.9 and in Table 2-3.

2.10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls (ICs).

Potential risks to human and ecological receptors are not posed by ingesting contaminated groundwater due to current land use conditions and the absence of exposure mechanisms, and no change in that status, land use, or groundwater use are anticipated. Contaminant concentrations in groundwater exceed USEPA's acceptable risk range and poses potential risks to future users of the groundwater as a drinking water source. Potential risks to human health through worker dermal contact and inhalation exists for construction and excavation activities. All alternatives, except Alternative 5, are protective of human health and the environment by maintaining incomplete exposure pathways.

Alternatives 2, 3, and 4 include monitoring and, thus, verification mechanisms to ensure that contaminant concentrations are continuing to decrease to levels below acceptable levels of potential risk to human and ecological receptors.

2.10.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The NCP requires that remedial actions at CERCLA sites at least attain ARARs, unless such ARARs are waived. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a

TABLE 2-3. COMPARATIVE ANALYSIS OF ALTERNATIVES
(Page 1 of 4)

Criteria	Alternative 1: Land Use Controls	Alternative 2: Groundwater Monitoring/Hydrologic Control	Alternative 3: <i>In Situ</i> Chemical Oxidation of the Entire Plume	Alternative 4: <i>In Situ</i> Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring	Alternative 5: No Action
Overall Protectiveness					
Human Health Protection - Groundwater Ingestion for Current Users	No current users.	No current users.	No current users.	No current users.	No current users.
Human Health Protection - Groundwater Ingestion for Potential Future Users	No future users anticipated, maintains incomplete exposure pathways for industrial scenario and for construction workers.	No future users anticipated, maintains incomplete exposure pathways for industrial scenario and for construction workers.	COC levels in aquifer estimated to achieve MCLs in less than 10 years.	No future users anticipated, maintains incomplete exposure pathways for industrial scenario and for construction workers.	No future users anticipated, does not maintain incomplete exposure pathways.
Environmental Protection	Maintains incomplete exposure pathways. No verification mechanisms.	Maintains incomplete exposure pathways. Provides verification mechanisms.	Maintains incomplete exposure pathways. Highest degree of protection due to destruction of contaminants. Provides verification mechanisms.	Maintains incomplete exposure pathways. Second highest degree of protection due to destruction of contaminants in high concentration areas. Provides verification mechanisms.	Maintains incomplete exposure pathways. No verification mechanisms.
Compliance with ARARs					
Chemical-Specific ARARs	Groundwater may exceed MCLs indefinitely.	Groundwater may exceed MCLs indefinitely.	May meet MCLs in less than 10 years.	Is expected to meet MCLs within 130 years.	Groundwater may exceed MCLs indefinitely.
Location-Specific ARARs	Meets location-specific ARARs.	Meets location-specific ARARs.	Meets location-specific ARARs.	Meets location-specific ARARs.	Meets location-specific ARARs.
Action-Specific ARARs	Meets action-specific ARARs.	Meets action-specific ARARs.	Meets action-specific ARARs.	Meets action-specific ARARs.	Meets action-specific ARARs.
Other Criteria and Guidance	Meets other criteria and guidance.	Meets other criteria and guidance.	Meets other criteria and guidance.	Meets other criteria and guidance.	Meets other criteria and guidance.
Long-Term Effectiveness and Permanence					
Residual Risk from Groundwater Ingestion for Current Users	No current users.	No current users.	No current users.	No current users.	No current users.

TABLE 2-3. COMPARATIVE ANALYSIS OF ALTERNATIVES
(Page 2 of 4)

Criteria	Alternative 1: Land Use Controls	Alternative 2: Groundwater Monitoring/Hydrologic Control	Alternative 3: <i>In Situ</i> Chemical Oxidation of the Entire Plume	Alternative 4: <i>In Situ</i> Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring	Alternative 5: No Action
Residual Risk from Groundwater Ingestion for Potential Future Users	Maintains incomplete exposure pathways. No verification mechanisms.	Maintains incomplete exposure pathways. Provides verification mechanisms.	Risk minimized by contaminant destruction. Drinking water quality restored in less than 10 years. Provides verification mechanisms.	Risk minimized by contaminant destruction. Drinking water quality restored within 130 years. Provides verification mechanisms.	Maintains incomplete exposure pathways. No verification mechanisms.
Adequacy and Reliability of Controls	Risks controlled by maintaining incomplete exposure pathways. Reliability of site access controls is high.	Risks controlled by maintaining incomplete exposure pathways. Reliability of site access controls is high.	Risks controlled by maintaining incomplete exposure pathways and destroying contaminants. Site access controls and chemical oxidation are reliable.	Risks controlled by maintaining incomplete exposure pathways and destroying contaminants in areas of highest contaminant concentrations. Site access controls and chemical oxidation are reliable.	No controls over contaminants. No reliability.
Reduction of Toxicity, Mobility, or Volume Through Treatment					
Treatment Process Used	None	None	Chemical oxidation of organics in groundwater.	Chemical oxidation of organics in groundwater.	None
Amount Destroyed or Treated	None	None	Up to 100% of chlorinated solvents above MCLs in groundwater through oxidation.	Approximately 23% of chlorinated solvents above MCLs in groundwater through oxidation.	None
Reduction of Toxicity, Mobility, or Volume	None	None	Reduced volume and toxicity of contaminants in groundwater.	Reduced volume and toxicity of contaminants in groundwater.	None
Irreversible Treatment	None	None	Destruction by chemical oxidation is irreversible.	Destruction by chemical oxidation is irreversible.	None
Type and Quantity of Residuals Remaining After Treatment	No treatment.	No treatment.	No residuals.	Residual contaminants in groundwater outside of treatment area of influence.	No treatment.
Short-Term Effectiveness					
Community Protection	No current risk to the community.	No current risk to the community.	No current risk to the community.	No current risk to the community.	No current risk to the community.
Worker Protection	No risk to workers.	Protection required against dermal contact with contaminated water during well sampling to limit risk.	Protection required against dermal contact with contaminated water and reagents during well sampling and injection to limit risk.	Protection required against dermal contact with contaminated water and reagents during well sampling and injection to limit risk.	No risk to workers.

TABLE 2-3. COMPARATIVE ANALYSIS OF ALTERNATIVES
(Page 3 of 4)

Criteria	Alternative 1: Land Use Controls	Alternative 2: Groundwater Monitoring/Hydrologic Control	Alternative 3: <i>In Situ</i> Chemical Oxidation of the Entire Plume	Alternative 4: <i>In Situ</i> Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring	Alternative 5: No Action
Environmental Impacts	No contaminant migration or further degradation of water quality.	No contaminant migration or further degradation of water quality.	No contaminant migration or further degradation of water quality.	No contaminant migration or further degradation of water quality.	No contaminant migration or further degradation of water quality.
Time Until Action is Complete	Indefinite.	Indefinite.	Less than 10 years.	Action is expected to be completed in approximately 130 years.	Indefinite.
Implementability					
Ability to Construct and Operate	No construction or operation.	Only well installation required.	Only well installation required. Straightforward injection process. Well installation and injection procedures would hinder mission-critical activities	Only well installation required. Straightforward injection process.	No construction or operation.
Ease of Doing More Action if Needed	Easy to maintain GIS indefinitely.	Easy to maintain GIS and monitor groundwater indefinitely.	After well installation, additional injection events are easy to initiate. Additional injection procedures could affect or disrupt mission-critical activities.	Additional injection events are easy to initiate.	No action.
Ability to Monitor Effectiveness	No monitoring.	Monitoring will provide verification mechanisms that exposure pathways remain incomplete.	Groundwater monitoring will verify that chemical oxidation is successful and complete.	Groundwater monitoring will verify chemical oxidation success and progress of natural process.	No monitoring.
Ability to Obtain Approvals and Coordinate with Other Agencies	No approvals necessary.	No permitting and minimal coordination required.	Intensive coordination with government agencies involved.	Intensive coordination with government agencies involved.	No approvals necessary.
Availability of Equipment, Specialists, and Materials	None required.	None required.	Readily available.	Readily available.	None required.
Availability of Technologies	None required.	Readily available.	Readily available.	Readily available.	None required.
Cost					
Capital Cost	\$2,800	\$159,600	\$43,948,100	\$464,300	\$0
Total O&M Cost	\$82,400	\$1,540,300	\$28,196,900	\$1,885,600	\$0
Total Periodic Cost	\$109,200	\$109,200	\$1,464,800	\$109,200	\$0
Present Value Cost	\$125,600	\$1,342,500	\$71,458,900	\$1,905,800	\$0

TABLE 2-3. COMPARATIVE ANALYSIS OF ALTERNATIVES
(Page 4 of 4)

Criteria	Alternative 1: Land Use Controls	Alternative 2: Groundwater Monitoring/Hydrologic Control	Alternative 3: <i>In Situ</i> Chemical Oxidation of the Entire Plume	Alternative 4: <i>In Situ</i> Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring	Alternative 5: No Action
Regulatory Agency Acceptance	Not acceptable.	Not acceptable.	Acceptable.	Acceptable.	Not acceptable.
Community Acceptance	No public comments specific to this alternative.	No public comments specific to this alternative.	No public comments specific to this alternative.	Acceptable.	No public comments specific to this alternative.

Notes:

ARAR = applicable or relevant and appropriate requirement
COC = chemical of concern
GIS = geographic information system
MCL = maximum contaminant level
O&M = operation and maintenance
TCE = trichloroethene

hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

The compliance with ARARs criterion addresses whether a remedy will meet all of the ARARs or other federal and state environmental statutes or provides a basis for invoking a waiver.

Alternatives 1, 2, and 5 may not comply with the identified ARARs. Alternatives 1 and 5 also have no compliance verification mechanisms. Alternative 3 achieves compliance with MCLs in groundwater and, thus, compliance with ARARs within 10 years. Alternative 4 is expected to achieve compliance with ARARs within approximately 130 years.

2.10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Although Alternative 1 may provide long-term effectiveness as long as LUCs are maintained and enforced indefinitely, it offers no protection verification mechanisms and does not reduce potential risks at the site. Alternative 2 offers protection verification mechanisms, and some effectiveness may be attributable to natural attenuation processes present at OU6. Alternatives 3 and 4 attain long-term effectiveness and permanence by reducing contaminant concentrations to MCLs that would allow unrestricted use and unlimited exposure to groundwater. Over time, the treated areas will affect the downgradient areas (by groundwater movement) and surrounding areas (by dilution and dispersion).

Alternatives 1, 2, and 5 will not likely reduce contaminant concentrations to below MCLs, even over an extended timeframe. Alternative 3 will reduce contaminant concentrations to below MCLs in less than 10 years. Based upon modeling results of an adjacent plume, Alternative 4 is expected to achieve compliance with ARARs within approximately 130 years.

Alternatives 2 and 4 would utilize the monitoring of OU6 conditions to ensure that contaminant concentrations are continuing to decrease to levels below those posing an unacceptable risk to human health and the environment. No monitoring would be utilized for Alternatives 1 and 5. Limited monitoring would be utilized for Alternative 3 because contaminant concentrations would be reduced below MCLs within 10 years. Minimal controls are necessary and the probable residual risk following the implementation of any of the alternatives would not exceed that which currently exists. Five-year reviews would be necessary to evaluate the effectiveness and protectiveness of Alternatives 1, 2, and 4 because groundwater contaminants would remain onsite at concentrations above MCLs for extended timeframes.

2.10.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternatives 1, 2, and 5 do not include treatment as a component of the remedy. These alternatives would not reduce the toxicity, mobility, or volume of contamination through treatment at OU6.

Alternative 3 includes treatment of VOCs throughout the entire groundwater plume as the main component of the remedy. Contaminant concentrations would be reduced to below MCLs over the entire plume area. This reduction is irreversible because the VOCs are chemically altered. Alternative 4 includes treatment of VOCs in the high concentration areas of the groundwater plume as a component of the remedy. Contaminant concentrations would be reduced to below MCLs in the areas of highest contaminant concentrations. This reduction is irreversible because the VOCs are chemically altered.

2.10.5 SHORT-TERM EFFECTIVENESS

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

None of the alternatives results in unacceptable short-term risks to the community or the environment, and all achieve protectiveness of any OU6 workers during remedial action implementation. During the implementation of Alternatives 3 and 4, permanganate would convert naturally occurring trivalent

chromium to hexavalent chromium, a carcinogen. However, the hexavalent chromium would be transitional and return to the trivalent form in groundwater once oxidation conditions degrade. During the implementation of Alternative 3, iron concentrations in the injected Fenton-based reagent are not expected to exceed those that occur naturally within the aquifer.

Alternatives 2, 3, and 4 involve conventional decontamination practices with standardized environmental monitoring procedures, personal protective equipment, and engineering controls to address concerns regarding contact with contaminated groundwater. Therefore, workers would be protected through the use of personal protective equipment during implementation of these alternatives.

2.10.6 IMPLEMENTABILITY

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Alternatives 1 and 5 would use no equipment beyond that currently utilized, and Alternative 2 would use conventional equipment and methods for groundwater sampling, analysis, reporting, and waste disposal.

Although Alternatives 3 and 4 would use conventional equipment for chemical injection, difficulty achieving dispersion of oxidizing agents in fractured bedrock may be encountered. The success of Alternative 3 would rely on the installation of 2,547 wells in roadways and taxiways. Such an implementation would compromise mission-critical activities by limiting aircraft movement.

All of the treatment alternatives, with the exception of Alternative 3, are easily implemented. The implementation of Alternative 3, although technically straight-forward, would require a massive mobilization of personnel and equipment and major disruption of mission-critical activities. All materials and services needed for implementation of any of the alternatives are readily, commercially available.

2.10.7 COST

The estimated present value costs for the alternatives, not including the No Action alternative, range from \$125,600 for Alternative 1 to \$71.5 million for Alternative 3. Cost summaries are presented in Table 2-3.

2.10.8 REGULATORY AGENCY ACCEPTANCE

Regulatory agency acceptance was evaluated based upon comments to the FS (Earth Tech, 2004). Federal and state agencies required an evaluation of an alternative that addresses groundwater contamination in the high concentration areas, making Alternatives 3 and 4 more favorable than Alternatives 1 and 2. Regulations mandate a remedial action, making Alternative 5 the least favorable alternative.

2.10.9 COMMUNITY ACCEPTANCE

A public comment period was provided during April and May 2005 so written or oral comments could be made. Comments are summarized in the Responsiveness Summary (Part 3). No public comments impacted the decision-making process or the intended selection of the remedial approach as presented in the PP.

2.11 PRINCIPAL THREAT WASTES

Principal threat wastes are source materials that are considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a potential risk considered to be unacceptable to human health or the environment should exposure occur. Source materials are materials that contain hazardous substances, pollutants, or contaminants that act as the starting point of contaminant migration to groundwater and may be highly toxic and not readily contained. Although groundwater is not usually considered a source material, NAPLs in groundwater may be considered such. Source materials and NAPLs were not identified at OU6.

No groundwater contaminant sources were identified in soil. The NCP establishes an expectation that treatment will be used to address principal threats posed by the sites wherever practicable. Because no source materials were identified at OU6, no principal threat wastes were targeted for treatment at OU6.

2.12 SELECTED REMEDY

2.12.1 SUMMARY OF THE RATIONALE FOR THE SELECTED REMEDY

The selected remedy for soil is No Action.

Alternative 4, the selected remedy for the groundwater, utilizes chemical oxidation treatment at the areas of highest contaminant concentrations, enhanced natural attenuation of aromatic hydrocarbons, hydrologic control (the natural aquifer characteristics that resulted in the steady-state condition of the plume), LUCs to maintain incomplete exposure pathways, and groundwater monitoring to address and monitor treatment performance.

The selected remedy is the most cost-effective and implementable remedial alternative for groundwater at OU6 that includes treatment and does not impact mission-critical activities. It will achieve compliance with ARARs and applies treatment as the primary component to degrade VOCs in groundwater for a significantly lower cost than Alternative 3.

2.12.2 DESCRIPTION OF THE SELECTED REMEDY

The selected remedy for soil is No Action.

The selected remedy for groundwater will include multiple components, some based on other alternatives. These components are LUCs, groundwater monitoring, *in situ* chemical oxidation, and 5-year reviews.

2.12.2.1 LUCs

The Air Force is committed to implement, monitor, maintain, and enforce remedies that protect human health and the environment in accordance with CERCLA and the NCP. DFRC is a tenant of Edwards AFB. The use of OU6 is restricted to research, development, and aerospace testing purposes. The 95th Air Base Wing, Environmental Restoration Branch (95 ABW/CEVR) works closely with NASA DFRC on all environmental issues and acts as a conduit to the USEPA and the State and will be involved in LUC implementation.

Implementation

The selected remedy requires LUCs to be in place during remediation of contaminated groundwater within the OU6 plume area where contaminant levels do not allow for unlimited use and unrestricted exposure. Figure 2-15 depicts the boundary of groundwater contamination requiring LUCs. The Air Force's commitment to include more specific LUC maps in the GP and NASA DFRC MP is discussed below.

LUC measures to be used at OU6 are in accordance with specific provisions of 22 California Code of Regulations (CCR) Section 67391.1 that were determined by the Air Force to currently be relevant and appropriate requirements. Subsections (a), (b), and (e)(2) of 22 CCR Section 67391.1 provide that if a remedy at property owned by the federal government will result in levels of hazardous substances remaining on property at levels not suitable for unlimited use and unrestricted exposure, and it is not feasible to record a land use covenant (as is the case with the OU6 sites subject to LUCs), then the ROD is to clearly define and include limitations on land use and other IC mechanisms to ensure that future land use will be compatible with the levels of hazardous substances remaining on the property. These limitations and mechanisms are more specifically set forth in this section of the ROD, to include annotating the residential development restrictions in the GP and MP, and continuing to follow the review and approval procedures for any construction and ground-disturbing activities within the OU6 LUC boundary.

The following LUCs apply to groundwater industrial controls for OU6. The objectives are to restrict residential development (including child development centers, kindergarten through 12th grade [K-12] schools, play areas, and hospitals) where contamination is at levels that do not allow for unlimited use and unrestricted exposure and to maintain worker safety. These goals will be achieved through the following:

- Annotating the residential development restrictions in the GP and MP
- Prohibiting residential development in designated areas set forth in the GP and MP
- Continuing administrative measures (described in the following paragraph)



EXPLANATION		Operable Unit 6 Land Use Control Boundary		
----- LAND USE CONTROL BOUNDARY				
		Date 09-2006	Operable Unit 6 Record of Decision Edwards AFB	Figure 2-15
		Project No. 54212		

These LUCs are accomplished by a prohibition on residential development in designated areas set forth in the GP and MP, and administrative measures. The administrative measures are the NASA DFRC Work Request procedures, the NASA DFRC Facilities Engineering Digging Permit procedures, and the Environmental Impact Assessment Process (EIAP). The EIAP, Work Request, and Facilities Engineering Digging Permit procedures restrict development during the interim period before remedial actions are implemented. A Facilities Engineering Digging Permit is required for any project that involves any mechanical soil excavation, such as digging trenches for underground lines or excavating soil for building foundations. The permit lists the DFRC Safety, Health, and Environmental Office and other support offices that review the excavation plans for approval. If constraints involving soil disturbance or worker safety exist at the excavation area, the permit describes the appropriate procedures that will prevent unknowing exposure to groundwater contamination and measures the workers must implement before the start of excavation.

The Air Force and/or NASA DFRC will implement the following measures at all sites with LUCs.

- Include in the GP and MP any specific restrictions required at each site, a statement that restrictions are required because of the presence of pollutants or contaminants, the current land users and uses of the site, the geographic control boundaries, and the objectives of the land use restrictions. Unless a site is cleaned up to levels appropriate for unlimited use and unrestricted exposure, the GP and MP will reflect the prohibitions on residential development (including child development centers, K-12 schools, play areas, and hospitals). Upon completion of a remedial action at a site, the GP and MP will be updated to modify the site-specific use restrictions as appropriate. The section describing the specific restrictions will also refer the reader to the Base Environmental Office or NASA DFRC Safety, Health, and Environmental Office, if more information is needed. The GP and MP will each contain a map depicting the geographic boundaries of all OU6 sites where LUCs are in effect.
- While LUCs are in place, maintain administrative control of the integrity of current and future remedial or monitoring systems and maintain existing administrative controls (presented in the subsequent section). LUCs will remain in place as long as groundwater contamination concentrations remain above levels allowing for unlimited use and unrestricted exposure. Neither the Air Force nor NASA DFRC will modify or terminate LUCs, implement actions, or modify land use without USEPA and California DTSC approval. The Air Force shall seek prior concurrence before any anticipated action (by the Air Force or NASA DFRC) that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.
- Whenever the Air Force transfers real property that is subject to ICs and resource use restrictions to another federal agency, the transfer documents shall require that the federal transferee include the ICs, and applicable resource use restrictions in its resource use plan or equivalent resource use mechanism. The Air Force shall advise the recipient federal agency of all obligations contained in the ROD, including the obligation that a State Land Use Covenant

will be executed and recorded pursuant to 22 CCR Section 67391.1 in the event the federal agency transfers the property to a non-federal entity.

- Whenever the Air Force proposes to transfer real property subject to resource use restrictions and ICs to a non-federal entity, it will provide information to that entity in the draft deed and transfer documents regarding necessary resource use restrictions and ICs, including the obligation that a State Land Use Covenant will be executed and recorded pursuant to 22 CCR Section 67391.1. The signed deed will include ICs and resource restrictions equivalent to those contained in the State Land Use Covenant and this ROD.
- The Air Force will provide notice to USEPA and the State at least 6 months prior to any transfer or sale of OU6 so that USEPA and the State can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for the facility to notify USEPA and the State at least 6 months prior to any transfer or sale, then the facility will notify USEPA and the State as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions above, the Air Force further agrees to provide USEPA and the State with similar notice, within the same time frames, as federal-to-federal transfer of property. The Air Force shall provide a copy of the executed deed or transfer assembly to USEPA and the State.
- NASA DFRC will notify the Air Force and the Air Force will notify the USEPA and the State at least 30 days in advance of any proposed land use changes that are inconsistent with LUC objectives or the selected remedy and any changes to the GP or MP that would affect the LUCs.
- NASA DFRC will notify the Air Force and the Air Force will notify the USEPA and the State as soon as practicable, but no longer than 10 days after discovery of any activity that is inconsistent with LUC objectives or use restrictions, or any action that may interfere with the effectiveness of LUCs, as well as provide the USEPA and the State within 10 days of notification of the breach with a tentative plan (including a timeline of proposed actions and delivery dates) regarding how the Air Force and NASA DFRC will address the breach or with a description of how the breach has been addressed.
- Address as soon as practicable any activity that is inconsistent with LUC objectives or use restrictions or any other action that may interfere with the effectiveness of LUCs, but in no case will the process be initiated later than 30 days after the Air Force and NASA DFRC becomes aware of the breach.
- NASA DFRC shall conduct periodic monitoring and take prompt action to restore, repair, or correct any LUC deficiencies or failures identified. A different monitoring schedule may be agreed upon according to the schedule provisions of the FFA, if all parties agree and if the change reasonably reflects the risk presented by the site.

It is understood that the Air Force is responsible for remedy implementation and ensuring integrity of the remedy. NASA DFRC, with oversight by the Air Force, is responsible for implementing (to the degree controls are not already in place), monitoring, maintaining, and enforcing the identified controls. If NASA DFRC and the Air Force determine that it cannot meet specific LUC requirements,

it is understood that the remedy may be reconsidered and that additional measures may be required to ensure the protection of human health and the environment.

In addition, to assure the USEPA and the State and the public that the Air Force will fully comply with and be accountable for the performance measures identified herein, NASA DFRC will supply information to the Air Force for, and the Air Force will timely submit to USEPA and California DTSC, an annual monitoring report on the status of LUCs and/or other remedial actions, including the operation and maintenance and monitoring thereof, and how any LUC deficiencies or inconsistent uses have been addressed. The report also will be filed in the information repositories. The report would not be subject to approval and/or revision by USEPA and the State. The annual monitoring reports will be used in preparation of the 5-year reviews to evaluate the effectiveness of the remedy and will verify that state and local agencies were notified of the use restrictions and controls affecting the property and that the use of the property has conformed to such restrictions and controls.

Availability of the Edwards AFB General Plan, NASA DFRC Master Plan, and Existing Administrative Procedures

The first step in restricting specific types of development at a site is to revise the GP and MP to place constraints ensuring that these sites are never used for residential development (including child development centers, K-12 schools, play areas, and hospitals). The GP resides in the office of the Base community planner, and the MP is available at the NASA DFRC Facilities Planning Office. Accordingly, the GP and MP will be revised to include residential development prohibitions and any specific restrictions required at each site, a statement that restrictions are required because of the presence of pollutants or contaminants, the current land users and uses of the site, the geographic control boundaries, and the objectives of the land use restrictions.

All proposed construction requires approval of the appropriate NASA DFRC office to ensure compliance with the GP and MP.

Form DFRC 8-0053, Facilities Work Request, must be submitted and approved before the start of any building project at NASA DFRC. Approval of the Work Request involves the comparison of the building site with the constraints in the MP. The Work Request serves as the document for communicating any construction constraints to the appropriate offices. Any constraints at the site result

in the disapproval of the form unless the requester makes appropriate modifications to the building plans. The DFRC Facilities Engineering and Asset Management Office (CODE F) is responsible for the final approval of proposed building projects through the Configuration Control Board review process.

NASA DFRC will also use form DFRC 8-0808, Facilities Engineering Digging Permit, to enforce the groundwater LUCs, as previously discussed. The requester submits the Facilities Engineering Digging Permit to the Facilities Office, CODE F, for any project that involves any mechanical soil excavation, and it is circulated to appropriate offices for review of needed safety procedures. The DFRC Facilities Engineering and Asset Management Office (CODE F) is responsible for the final approval of excavation projects through the permit review process.

Both the Work Request and Facilities Engineering Digging Permit are subject to an EIAP review conducted pursuant to the National Environmental Policy Act, as promulgated for NASA in 14 Code of Federal Regulations (CFR) Part 1216 Subpart 1216.3. The EIAP analysis is initiated when a proponent of a proposed action fills out a form DFRC 8-0039, Request for Environmental Impact Analysis. A proponent of an action is required to submit the Work Request and/or Facilities Engineering Digging Permit with the form DFRC 8-0039 to the Safety, Health, and Environmental Office so that the appropriate environmental analysis of the proposed action and alternatives to the proposed action is accomplished prior to any construction activities. The NASA DFRC environmental staff (air, water, cultural and natural resources, restoration, and others) and the community planner review DFRC forms 8-0039 that involve facilities construction. Major new construction may result in a determination that a formal publicized Environmental Assessment is necessary. The EIAP process works to ensure proposed construction sites are reviewed in accordance with the MP. The process also ensures that all environmental factors, as well as the Base's ROD LUCs, are considered in siting construction projects.

Cleanup Levels

Based on the current industrial land use and the reasonably foreseeable future long-term land use that is projected to be industrial, potential risks associated with COCs in groundwater are mitigated by the lack of complete exposure pathways. However, should the groundwater at OU6 ever be used for beneficial purposes, ingestion of the water from this aquifer would pose a potential risk to human health because

of MCL exceedances. Therefore, MCLs were selected as the cleanup levels for groundwater and are presented in Table 2-4.

Once OU6 achieves the cleanup levels for groundwater, then the site is available for unlimited use and unrestricted exposure, and there is no need to establish, maintain, monitor, report on, or enforce LUCs. The USEPA and the State agree to delete LUCs requirements once the groundwater achieves the cleanup levels for all COCs.

2.12.2.2 Groundwater Monitoring

Groundwater monitoring will be conducted to track treatment performance, verify plume containment, and document achievement of the cleanup standards and compliance with ARARs. Treatment performance consists of transport of oxidant throughout the plume by advection, dispersion, and diffusion and the ensuing degradation of contaminants by abiotic and potentially biotic mechanisms. Plume containment is based on observed plume stability and shrinkage, verified by existing monitoring data indicating that the high contaminant concentration areas have been reduced significantly and the leading edge of the plume is retreating westward despite continued natural eastward groundwater movement. Wells both within and outside the plume will be monitored to establish that treatment is occurring, to calculate a degradation rate if possible in order to verify performance against the modeling predictions, and to ensure that plume behavior does not change in any unexpected ways that might threaten the regional aquifer 1 mile downgradient (Leighton and Phillips, 2003). If any unexpected behavior is observed during the groundwater monitoring, the next 5-year review will include a contingency plan to capture anomalous migration of contaminants. This approach will be sufficiently protective because the most conservative assumption is that the contaminants could start to move eastward at the rate of groundwater movement; since this is approximately 42 feet per year, more than 100 years' migration could occur before there would be a significant threat to the regional aquifer.

Groundwater monitoring purge water free of sodium permanganate will be carbon treated and discharged to the Base sanitary sewer system. Purge water containing sodium permanganate will be gravity fed into high concentration injection wells in lieu of carbon treatment and discharge to the sanitary sewer.

TABLE 2-4. GROUNDWATER CLEANUP LEVELS

Chemical of Concern	MCL (µg/L)
1,1,2,2-tetrachloroethane	1
1,1,2-trichloroethane	5
1,1-dichloroethane	5
1,2-dibromoethane (ethylene dibromide)	0.05
1,2-dichloroethane	0.5
<i>cis</i> -1,2-dichloroethene	6
<i>trans</i> -1,2-dichloroethene	10
1,2-dichloropropane	5
benzene	1
carbon tetrachloride	0.5
chloroform	80
ethylbenzene	300
methylene chloride	5
toluene	150
trichloroethene (TCE)	5
vinyl chloride	0.5
total xylenes	1,750

Notes:

µg/L = micrograms per liter

MCL = maximum contaminant level (California DHS, 2003)

2.12.2.3 *In Situ* Chemical Oxidation

There are no soil or groundwater source areas, but the selected alternative will include *in situ* chemical oxidation of contaminants at the plume areas of highest contaminant concentration. A total of 22 existing wells will be used for injection of chemical oxidation reagent and multiple applications may be necessary. The injection time intervals, number of events, and remedial action duration will be determined during the remedial design phase and further refined based upon injection monitoring results. Additionally, limited-scale enhanced natural attenuation (bioremediation) using a food-grade oxygen-release compound will be undertaken at some Site N3 wells to accelerate biodegradation of aromatic hydrocarbons.

2.12.2.4 Five-Year Reviews

Reviews will be performed every 5 years for as long as contaminants at OU6 remain at levels that do not allow for unrestricted use. The 5-year reviews and associated groundwater monitoring data will be placed in the post-ROD Administrative Record for OU6. Supporting documentation, including groundwater monitoring results, will be used to evaluate progress toward reducing concentrations to or below MCLs and otherwise assess whether human health and the environment are adequately protected by the implemented remedial action.

2.12.3 SUMMARY OF THE ESTIMATED REMEDY COSTS

The information in this cost estimate is based on the analysis completed in the FS (Earth Tech, 2004) and is the best available information regarding the anticipated remedial alternative scope. Changes in the cost elements are likely to occur as a result of new information and data collected during the remedial alternative engineering design. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within the range of 50 percent above and 30 percent below the actual project cost.

The project duration is unknown and will be based upon the results of the groundwater monitoring following remediation activities. Cost estimates are provided for a 30-year duration. The project duration, number of injection events, and schedule of injection events will be determined based upon conditions encountered in the field and groundwater monitoring results.

2.12.3.1 Cost Estimates

Cost estimates prepared for the FS (Earth Tech, 2004), and summarized here, represent three cost types: capital costs, O&M costs, and periodic costs.

Capital costs are associated with the construction and initial implementation of a remedial action and do not include costs associated with long-term operation. The costs include labor, equipment, material costs, contractor markups, mobilization/demobilization, site work, installation, disposal, and expenditures for supporting professional/technical services associated with construction of the remedial action (Table 2-5).

The estimate for capital costs is based on the installation of one new monitoring well and three mobilizations and injection events. Permanganate reagent will be injected into 22 wells during each of the three events. Costs associated with groundwater monitoring include the sampling of 41 wells during the first year, associated laboratory analysis, and purge water disposal. Additional injection events may be necessary based upon conditions encountered in the field and groundwater monitoring results. Geographic information system (GIS) maintenance for the first year is also included in capital costs.

O&M costs are those post-construction costs incurred to verify the effectiveness of a remedial action. O&M costs were estimated for each year and include labor, equipment, material costs, and contractor markups associated with monitoring and professional/technical services.

Costs associated with groundwater monitoring include the sampling of 41 wells per event, with one event per year during calendar years 2 through 5; 1 event every 2 years until calendar year 11; 1 event every 5 years until calendar year 26; and a final event (for cost estimating purposes) in calendar year 30. Estimated costs are also included for on-site carbon treatment of purge water and transport to the on-site treatment facility. Annual GIS maintenance costs are also included in the O&M costs.

Periodic costs generally occur either 1) once every few years or 2) once during the remedial timeframe. Periodic costs included in these estimates are associated with 5-year reviews, which will be performed during calendar years 6, 11, 16, 21, and 26, and following site closeout activities.

TABLE 2-5. COST SUMMARY FOR SELECTED REMEDY (ALTERNATIVE 4)

Cost Type	Component/Description	Quantity	Unit	Unit Cost	Cost
Capital Costs	Land Use Controls				
	First Year GIS Maintenance	24	Hour	\$118	\$2,843
	Monitoring				
	Well Installation	1	Well	\$17,531	\$17,531
	Waste Disposal	1	Well	\$4,542	\$4,542
	First Year Monitoring	1	Total	\$163,927	\$163,927
	Purge Water Treatment/Discharge	1	Total	\$5,128	\$5,128
	Chemical Oxidation				
	Mobilization	1	Each	\$63,321	\$63,321
	Permanganate	22	Well	\$245	\$5,390
	Field Support	22	Well	\$3,589	\$78,958
	Engineering Support	65	Hour	\$125	\$8,125
	Equipment	22	Well	\$5,087	\$111,914
Operation and Maintenance	GIS Maintenance	696	Hour	\$118	\$82,434
	Monitoring	1	Total	\$1,803,197	\$1,803,197
Periodic	5-Year Reviews	1	Total	\$109,207	\$109,207 ¹
				Total:	\$2,456,517²

Notes:

All costs include mark-ups and are not escalated.

See Feasibility Study (Earth Tech, 2004) for definitions of cost-related terms.

¹Cost includes multiple 5-year reviews.

²Cost differs slightly from the total nonescalated cost presented in the Feasibility Study due to change in GIS maintenance approach.

GIS = geographic information system

2.12.3.2 Escalation and Present Value

Escalation

Escalation is a cost adjustment utilized to account for the change of labor rates, productivity, and material prices that occur between the cost estimate date and the date on which work will be performed. An escalation factor is applied to each year's total expenditures for the duration of the project.

Discount Rate

The discount rate is used in present value analysis to adjust for the potential productivity and increasing value of money, assuming positive-return investments. A 3.2-percent discount rate was selected based upon the rates published in Appendix C to *Circular A-94 - Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (United States Office of Management and Budget, 2003).

Present Value

Present value analysis is a method to evaluate and compare expenditures that occur over varying project durations. This methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This "present value" is the amount needed to be set aside at the project outset to assure that funds will be available for the entire project.

Based on the capital costs, the annual monitoring (O&M) costs, and the periodic costs (5-year reviews), the total present value of the selected remedy is estimated to be approximately \$1,905,800 (Table 2-6). The value of the selected remedy is higher than Alternatives 1, 2, and 5 (\$125,600, \$1,342,500, and \$0, respectively), and significantly lower (weighing heavily in the selection decision) than Alternative 3 (\$71,458,900).

2.12.4 EXPECTED OUTCOME OF THE SELECTED REMEDY

The selected remedy for OU6 will address risks presented by the potential dermal and inhalation pathways of exposure to groundwater and groundwater vapors to workers who may perform subsurface tasks and will provide for protection of those workers during remedy implementation. The selected remedy for OU6 will address the potential risks to human health from ingestion of contaminated groundwater and will restrict the use of the land and groundwater to prohibit sensitive and residential

TABLE 2-6. SUMMARY OF ESCALATED COSTS AND PRESENT VALUE OF SELECTED REMEDY

Year	Capital Cost	Operation and Maintenance Cost	Periodic Cost	Total Cost
1	\$500,561	--	--	\$500,561
2	--	\$183,764	--	\$183,764
3	--	\$187,816	--	\$187,816
4	--	\$191,952	--	\$191,952
5	--	\$196,188	--	\$196,188
6	--	\$3,418	\$25,442	\$28,860
7	--	\$204,894	--	\$204,894
8	--	\$3,567	--	\$3,567
9	--	\$213,632	--	\$213,632
10	--	\$3,716	--	\$3,716
11	--	\$222,371	\$29,200	\$251,571
12	--	\$3,865	--	\$3,865
13	--	\$3,940	--	\$3,940
14	--	\$4,015	--	\$4,015
15	--	\$4,089	--	\$4,089
16	--	\$244,235	\$32,218	\$276,453
17	--	\$4,238	--	\$4,238
18	--	\$4,313	--	\$4,313
19	--	\$4,387	--	\$4,387
20	--	\$4,462	--	\$4,462
21	--	\$266,098	\$35,181	\$301,279
22	--	\$4,611	--	\$4,611
23	--	\$4,685	--	\$4,685
24	--	\$4,760	--	\$4,760
25	--	\$4,834	--	\$4,834
26	--	\$287,962	\$38,158	\$326,120
27	--	\$4,983	--	\$4,983
28	--	\$5,058	--	\$5,058
29	--	\$5,132	--	\$5,132
30	--	\$305,439	--	\$305,439
Totals	\$500,561	\$2,607,866	\$134,757	\$3,243,186
Present Value at 3.2%:		\$1,905,800		

uses during remedy implementation. The selected remedy will reduce VOC concentrations in groundwater to below MCLs, restoring groundwater quality.

The selected remedy maintains the current OU6 industrial activities, does not impact current or anticipated (industrial) OU6 uses, and will meet the RAOs. The time to achieve MCLs in groundwater through treatment and natural processes is approximately 130 years. Beneficial groundwater uses will be available following remedial action completion.

Minimal environmental impacts are expected from implementation of the selected alternative. It will have no adverse impacts on ecological or cultural resources. No adverse human health impacts from the remedial action are anticipated to occur on or off Base. No local socioeconomic or community revitalization impacts are anticipated.

2.13 STATUTORY DETERMINATIONS

The selected remedy will comply with the substantive portions of all ARARs. Section 121(e) of CERCLA, United States Code (U.S.C.) Section 9621(e), states that no federal, state, or local permit is required for remedial actions conducted entirely onsite; these actions must meet the substantive but not administrative requirements of the ARARs.

2.13.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy, Alternative 4 - *In Situ* Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring, will protect human health and the environment by maintaining the current incomplete exposure pathways (e.g., inhalation of groundwater vapors, dermal contact, and ingestion) through OU6 access limitations (i.e., LUCs). The remedial approach will chemically alter contaminants in the areas of highest groundwater concentrations. Potential risks to human and ecological receptors are not posed by site-related substances due to the absence of exposure mechanisms and land use conditions, and no change in that status, land use, or groundwater use are anticipated. The remedial approach includes monitoring and, thus, verification mechanisms to ensure that contaminants remain at reduced or current concentrations, exposure pathways remain incomplete, and migration does not occur. The time to achieve MCLs in groundwater through treatment and natural processes is approximately 130 years; beneficial

groundwater uses will be available, although none are anticipated. During the chemical oxidation process, reagents and injection activities will be carefully controlled and will not pose unacceptable short-term risks or cross-media impacts. The current OU6 industrial activities will be maintained, and the selected alternative will not impact current or anticipated (industrial) OU6 uses.

2.13.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The selected remedy will comply with all federal and state ARARs identified for the remedial action for the OU6 groundwater contaminant plume (Appendix A).

2.13.3 ARARs

2.13.3.1 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based numerical values that, when applied to site-specific conditions, establish acceptable concentrations of a chemical that may be found in, or discharged to, the ambient environment. If a chemical has more than one cleanup level, the most stringent level is identified as an ARAR for this remedial action. Substantive provisions of the following requirements were identified as the most stringent of the potential federal and state groundwater ARARs for OU6 remedial actions:

- federal MCLs listed in the Safe Drinking Water Act
- state primary MCLs in 22 CCR

The selected alternative is based on State Water Resources Control Board (SWRCB) Resolution 88-63's classification of all groundwater in the state as a potential source of drinking water (if the water meets certain quality criteria) and the CRWQCB's designation of the groundwater at OU6 as potential drinking water, and complies with state and federal MCLs. The Air Force has determined that the SWRCB Resolution 92-49 requirement to "clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored" is not an ARAR for the purpose of this remedial action. Notwithstanding that determination (see Air Force and NASA DFRC, USEPA, and State of California positions discussed below), the Air Force has met the intent of SWRCB Resolution 92-49 by conducting a Technical and Economic Feasibility Analysis (TEFA) in accordance with the resolution's direction: "...in applying any alternative cleanup levels less stringent than background, apply

Section 2550.4 of Chapter 15 [of 23 CCR].” The selected remedy complies with the substantive requirement of SWRCB Resolution 92-49 to either achieve background water quality or show by analysis what water quality is achievable by conducting a TEFA (see Section 2.13.4). The TEFA was conducted in accordance with 23 CCR Section 2550.4 as referenced in SWRCB Resolution 92-49.

Air Force’s and NASA DFRC’s Position

The Air Force’s and NASA DFRC’s position is that all remedial actions under CERCLA must, as a threshold matter, be determined by the lead agency to be necessary to protect human health and/or the environment from unacceptable risk, and further be appropriate and relevant to the circumstances of a site release (42 U.S.C. Section 9621(a)(1) and (d)(1)). Both CERCLA and the NCP focus on cleaning up contaminated groundwater, where practicable and achievable within a reasonable timeframe, to a level that will restore the designated uses of the groundwater, not to the lowest level achievable regardless of risk (42 U.S.C. Section 9621(d)(2)(B)(i) and 40 CFR Section 300.430(a)(1)(iii)(F)). Accordingly, California nondegradation provisions (to include SWRCB Resolution 92-49 and the Basin Plan) based on achieving background or the lowest cleanup level that is technically and economically achievable are not risk-based, necessary, appropriate or relevant to returning contaminated groundwater to a drinking water level of service; and, therefore, they are not eligible for consideration as potential ARARs.

Regarding applicability, and without prejudice to the Air Force’s and NASA DFRC’s position above, the California nondegradation provisions are not applicable as they are directed towards state agencies who in turn are directing cleanup under state law, whereas this is a federal CERCLA cleanup action where the state is a support agency; or apply to current discharges as opposed to historic releases or further migration of such releases; or apply to specific, discrete regulated units that received hazardous waste after July 26, 1982, neither of which apply here.

State nondegradation provisions are not relevant and appropriate requirements (RARs) because: MCL goals that are set at zero are categorically not relevant and appropriate (40 CFR Section 300.430(e)(2)(i)(C)) and as background for the hazardous substances in issue at Edwards AFB OU6 would be zero, such background provisions in California nondegradation provisions are similarly not relevant and appropriate; 40 CFR Section 300.430(e)(2)(i)(C) and 40 CFR Section 300.400(g)(2)(viii)

together require that a potential RAR for groundwater reasonably relate, that is be relevant and appropriate, to the beneficial use of the groundwater being addressed and as discussed above, California nondegradation provisions requiring cleanup levels be set at zero or the lowest level technically and economically feasible, are not reasonably related to any actual or potential use of the water or risks to users thereof; and the CCR revisions are designed for specific and discrete units that manage hazardous waste, such as landfills, surface impoundments, and other similar transfer, treatment, storage or disposal units, thus they are not reasonably related to the diffuse release sites at Edwards AFB.

Based upon all the above, the only provisions of the California regulations that are potential ARARs are those that direct cleanup concentrations or levels not more stringent than federal and state MCLs. To the extent state MCLs are the same as federal, they are not more stringent, and thus not ARARs. If a state MCL is more stringent, then that is an ARAR under CERCLA—see 42 U.S.C. Section 9621(d)(2)(A)(ii).

USEPA's Position Regarding State Requirements as ARARs for OU6

Only State standards, requirements, criteria, or limitations that have been promulgated under state environmental or facility-siting laws that are more stringent than federal ARARs and that have been identified by the State of California in a timely manner are potential state ARARs.

With regard to the Basin Plan, it is the USEPA's position that only those parts of the Basin Plan which set out the designated uses (beneficial uses) and the water quality criteria based upon such uses (water quality objectives) meet the NCP's definition of substantive standards. Other parts of the Basin Plan express general goals and/or enumerate factors that the Regional Boards consider in the process of enforcing water quality standards; these do not set standards themselves.

With regard to SWRCB Resolution 92-49, only Section III.G has substantive standards that are potentially relevant and appropriate to CERCLA groundwater cleanups. The first three pages of SWRCB Resolution 92-49 contain the whereas clauses, followed by Sections I and II which state the policies and procedures that the Regional Boards apply in overseeing cleanups.

Likewise, Sections III.A through E simply enumerate the factors the Regional Boards have to consider in implementing cleanups. Section III.F requires the Regional Board to require cleanup actions to

conform to Resolution 68-16 and implement the provisions of Chapter 15 that are applicable to the cleanup activity. While Resolution 68-16 and Chapter 15 regulations have substantive requirements that impact cleanup standards, these two state requirements have to be analyzed in and of themselves as to whether they are potential ARARs, independent of their incorporation by reference to SWRCB Resolution 92-49. It is the USEPA's position that Resolution 68-16 is an ARAR when setting limits for discharge or reinjection into groundwater.

It is not an ARAR for setting aquifer cleanup standards in CERCLA groundwater cleanup. This is because the USEPA does not believe that continuing migration of contamination in groundwater is a "discharge" subject to Resolution 68-16. Regarding Chapter 15, it is the USEPA's position that Chapter 15 has limited applicability to CERCLA cleanups because of the exemption language in Section 2511(d) which generally exempts cleanups taken by or at the direction of public agencies. Incorporation of Resolution 68-16 and Chapter 15 into SWRCB Resolution 92-49 does not broaden the applicability of these two state regulations outside these parameters.

With regard to secondary MCLs, the USEPA has consistently stated that these are not ARARs because they are not promulgated federal environmental standards that go to the protection of human health and the environment. Even when promulgated by the State, secondary MCLs address taste and odor. The USEPA considers taste and odor cosmetic, not health-based environmental standards. The NCP remedy selection process is founded on CERCLA's overarching mandate to protect human health and the environment.

State of California's Position Regarding State Requirements

The State of California has identified SWRCB Resolution 92-49 and 23 CCR Section 2550.4 as proposed ARARs for determining cleanup levels for VOCs in the groundwater at Edwards AFB. The Air Force and the State disagree about whether these state requirements are ARARs for this cleanup.

With respect to SWRCB Resolution 92-49, the State asserts that this resolution is an applicable requirement for remedial actions of the contaminated groundwater and complies with 23 CCR Section 2550.4. Furthermore, the State does not believe that the application of SWRCB Resolution 92-49 is strictly limited to Section III.G. In this case, SWRCB Resolution 92-49 requires remediation of the contaminated groundwater to the lowest concentration levels of constituents technically and

economically feasible, which must at least protect the beneficial uses of groundwater, but need not be more stringent than is necessary to achieve background levels of the constituents in groundwater.

Pertaining to SWRCB Resolution 68-16, Resolution 68-16 is an ARAR for the injection of any discharge of waste or proposed discharge of waste into groundwater and is not strictly limited to a discharge of waste to treat contaminants. Waste is defined pursuant to Water Code Section 13050, Subdivision (d), and includes, but is not limited to, permanganate. A discharge also occurs where polluted groundwater migrates to areas of high quality groundwater. Discharges subject to Resolution 68-16 include the continuing migration of any *in situ* treatment reagents or other waste as defined in Water Code Section 13050, Subdivision (d) from the injection wells to groundwater. Under Resolution 68-16, some degradation may be allowed so long as the cleanup action applies best practicable treatment and control to prevent further migration of waste to waters of the State at levels that exceed water quality objectives or impact beneficial uses. "Waters of the State" includes surface water and groundwater pursuant to Water Code Section 13050, Subdivision (e).

With respect to 23 CCR Division 3, Chapter 15, the State asserts that Chapter 15 regulates all discharges of hazardous waste to land that may affect water quality. A "waste management unit" is defined in Chapter 15 as "an area of land, or a portion of a waste management unit, at which waste is discharged" (23 CCR Section 2601). Pursuant to Water Code Section 13050, Subdivision (d), the definition of "waste" is extremely broad and includes the injection of one or more chemicals to groundwater to the extent that there is a discharge to an "area of land".

23 CCR Section 2550.4 requires the consideration of beneficial uses when establishing cleanup levels above background. The factors that are to be considered by Edwards AFB in performing a TEFA for groundwater are listed under Section 2550.4(d). Section 2550.6 requires monitoring for compliance with remedial action objectives for 3 years from the date of achieving cleanup levels. Section 2550.10 requires implementation of corrective action measures that ensure Title 23 cleanup levels are achieved through the zone affected by the release by removing waste constituents or by treating them in place.

With respect to the Basin Plan, the State asserts that Chapter 2, *Beneficial Uses*, and the sections in Chapter 4, *Implementation* entitled "Requirements for Site Investigation and Remediation" and

“Cleanup Levels” are ARARs and apply to determine the appropriate cleanup level in groundwater to protect beneficial uses and to meet the water quality objectives.

With respect to secondary MCLs, the State asserts that the taste and odor water quality objective specified in the Basin Plan for the Lahontan Region, which incorporates State primary and secondary drinking water standards, is an ARAR that applies to the establishment of cleanup levels in OU6. In particular, secondary MCLs for taste and odor based on drinking water standards specified in Table 64449-A (Secondary Maximum Contaminant Levels - Consumer Acceptance Limits) and Table 64449-B of Section 64449 (Secondary Maximum Contaminant Levels - Ranges) of the Basin Plan are ARARs.

In short, (1) SWRCB Resolution 92-49; (2) Chapter 2, Beneficial Uses, Chapter 3, Water Quality Objectives, and the Sections “Requirements for Site Investigation and Remediation” and “Cleanup Levels” from Chapter 4, *Implementation*, of the Basin Plan; (3) 23 CCR Division 3, Chapter 15; and (4) secondary MCLs are applicable requirements because they specifically address remedial actions taken in order to protect the quality of the waters of the State. They are substantive requirements that are legally enforceable, of general applicability, and more stringent than federal requirements. Furthermore, although the Air Force has recognized the applicability of SWRCB Resolution 68-16, the State notes that the appropriate scope of the applicability of SWRCB Resolution 68-16 in this particular case is subject to some disagreement between the Air Force and the State.

Summary

The Air Force conducted a qualitative TEFA (see Section 2.13.4) in 2006 of achieving cleanup levels more stringent than federal or state MCLs for groundwater cleanup. The results of the TEFA indicated that achieving background levels of constituents in the groundwater is not technically and economically feasible. All parties agree with the technical sufficiency of the TEFA, and all parties agree that the cleanup objective of the lowest levels technically and economically feasible based on a TEFA provides substantive compliance with SWRCB Resolution 92-49 and 23 CCR Section 2550.4. The criteria are intended to result in cleanup to the lowest level that is technically and economically feasible and that will protect beneficial uses of the waters of the State. All parties agree that, at this time, cleanup levels for all VOCs in the groundwater at OU6 are state or federal MCLs, whichever is more stringent.

The Parties, however, desire to avoid disputing this issue, particularly if, in utilizing the state nondegradation provisions and the TEFA analyses therein, a joint determination can be made that cleanup to background for site hazardous substances is not technically and economically feasible. The parties acknowledge that one factor specified in the NCP for determining the relevance and appropriateness of any requirement are variance, waiver or exemption provisions specified in the requirement (40 CFR Section 300.430(g)(2)(v)). Accordingly, without prejudice to the positions of the respective parties, which all parties have respectively reserved and preserved, and without any precedence, the Air Force conducted an analysis of the technical and economic feasibility of achieving cleanup levels more stringent than MCLs. In so doing the Air Force is neither directly or indirectly acknowledging that either levels below MCLs or the TEFA process itself are ARARs. The Air Force has determined that it is not technically or economically feasible to clean the groundwater at Edwards AFB OU6 to background for all hazardous substances, and that it is not necessary to do so, in this particular case, to protect human health and the environment. The USEPA and the State agree with this analysis and determination, and all parties agree that the CERCLA and NCP compliant cleanup levels for all site hazardous substances in the groundwater shall be the MCLs. The State further concurs that such levels will not pose a substantial threat or potential hazard to human health.

2.13.3.2 Location-Specific ARARs

Location-specific ARARs are restrictions on the concentrations of hazardous substances or on activities solely because they are in specific locations such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. All location-specific ARARs identified for this remedial action are state requirements in 14 CCR:

- California Endangered Species Act
- Fish and Wildlife Protection and Conservation regulations
- Wildlife Species/Habitats regulations
- Mammals and Reptiles Provisions
- Rare Native Plants regulations

The selected alternative will comply with location-specific ARARs.

2.13.3.3 Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or limitations that apply to particular remedial activities. The primary action-specific ARARs identified for this remedial action are:

- Generators of Hazardous Waste standards in 40 CFR Part 262 and 22 CCR
- Underground Injection Control Program in 40 CFR Parts 144 et seq.
- State non-degradation policy in SWRCB Resolution 68-16
- State beneficial-use designations for groundwater in SWRCB Resolution 88-63

This remedial action will comply with the hazardous waste generators standard by characterizing soil cuttings from well installation (if any), purge water extracted from monitoring wells, and spent carbon from purge water treatment, and disposing of these substances properly including packaging, labeling, marking, placarding, and accumulation before final disposal. Resolution 68-16 and the Underground Injection Control Program apply to injection or reinjection of the treatment reagent, sodium permanganate (or any other reagent), and the reinjection of treated water. Compliance will be achieved by monitoring OU6 groundwater for complete reaction of the permanganate and by reinjecting only in already-degraded portions of the groundwater, at existing high contaminant concentration areas. Compliance with the state beneficial-use designation of all state groundwater as potential drinking water will be achieved by implementing the best economically achievable treatment practice and by establishing attainment of drinking water standards as the cleanup goal.

2.13.4 TECHNICAL AND ECONOMIC FEASIBILITY ANALYSIS

This TEFA for remediating the contaminants of concern in OU6 groundwater to background levels is intended to satisfy requirements for corrective action under SWRCB Resolution 92-49. SWRCB Resolution 92-49 authorized Regional Water Boards to require complete cleanup of all waste discharged and restoration of affected water to background condition, or if achieving background is shown to be technologically or economically infeasible, some agreed higher concentration limit that is technically and economically feasible; but in no event shall a concentration limit greater than background exceed the MCL established under the federal Safe Drinking Water Act (22 CCR Section 64444). TCE is the primary contaminant in OU6 groundwater and will govern both the technical and economic practicability of groundwater restoration to background conditions. For the purpose of this analysis,

0.5 µg/L is considered equivalent to the background level for TCE, consistent with California Department of Health Services Detection Limits for Purposes of Reporting for Regulated Chemicals found at <http://www.dhs.ca.gov/ps/ddwem/chemicals/DLR/dlindex.htm>.

OU6 groundwater contaminants occur in fine-grained lacustrine and alluvial sediments and fractured granitic rock with low effective permeabilities and low sustainable pumping rates. Based on these hydrogeologic conditions, site-specific treatability study results, and several studies that have assessed the performance of pump-and-treat systems across the nation to achieve cleanup goals (National Research Council [NRC], 1994), only *in situ* methods were considered for complete evaluation and cost estimating in the OU6 FS. This TEFA for remediation of TCE in groundwater to background levels is based on Alternatives 3 and 4 from the FS. Both remedial alternatives are based on *in situ* chemical oxidation technologies, which would need to be implemented over a larger area and/or a longer time than is provided for in the FS to achieve reduction of contamination from MCLs to background levels.

2.13.4.1 Environmental Factors

In order to comply with 23 CCR, Section 2550.4 as referenced in SWRCB Resolution 92-49, the Air Force considered nine groundwater-related environmental factors in evaluating technical and economic feasibility for OU6 cleanup to background levels. These factors, in Section 2550.4(d)(1), Subsections (A) through (I), are discussed here.

(A) Physical and chemical characteristics of the waste in the waste management unit:

OU6 groundwater contaminants consist of chlorinated and aromatic VOCs. The industrial solvent TCE is the primary contaminant. All contaminants occur in the dissolved phase; no nonaqueous phase liquids are suspected. The contaminants can be oxidized and broken down to non-toxic compounds such as manganese dioxide and chloride and hydronium ion.

(B) Hydrogeological characteristics of the facility and surrounding land:

Groundwater at OU6 occurs partly in fine-grained lacustrine and alluvial sediments, but primarily in fractured granitic rock with low effective permeabilities and low sustainable pumping rates. The boundary of the regional aquifer has been mapped by the USGS (Leighton and Phillips, 2003) more than 1 mile downgradient.

(C) Quantity of groundwater and direction of ground water flow:

Quantities of groundwater in the alluvium are low to moderate; in the fractured rock, very low. Aquifer tests conducted during the OU6 RI indicate that the yield of most wells is between 0.6 gallon per minute (gpm) and 2.5 gpm, with a maximum yield of 3.0 gpm (Earth Tech, 2000), or 4,320 gallons per day. The hydraulic gradient is eastward toward Rogers Dry Lake; beyond the OU boundary the gradient turns northward. Average groundwater velocity is 0.12 foot per day or 42 feet per year. Low quantities of water and low permeabilities have been the principal challenge to remediation technologies evaluated in treatability studies at OU6.

(D) Proximity and withdrawal rates of ground water users:

There are no current users of groundwater at OU6. The nearest on-base water supply well is production Well N-2 at the north end of Rogers Dry Lake, about 3 miles north of OU6. This well has recently been removed from service because of high arsenic content. The next nearest production well is 5.5 miles north at the Fountain Trailer Park on Highway 58.

(E) Current and potential future uses of ground water in the area:

There are no current or planned domestic uses of groundwater at OU6. In addition to Well N-2, there are Base production wells at the south end of Rogers Dry Lake, about 8 miles cross-gradient, and to the southeast across the lakebed, upgradient. Currently the Base buys water from Antelope Valley-East Kern Water Agency (AVEK), a State Water Project contractor, for blending with locally produced water to meet arsenic standards. Base Civil Engineering's long-term water supply plan is to reduce or eliminate production from high-arsenic wells in the north part of the Base and replace this supply by production from new wells in the south part of the Base.

(F) Existing quality of ground water:

Groundwater is moderately alkaline, and varies from sodium chloride type to sodium sulfate-chloride to sodium bicarbonate. Total dissolved solids range from 286 milligrams per liter (mg/L) to 55,800 mg/L, averaging 7,107 mg/L. Hardness ranges from 20.1 mg/L to 8,420 mg/L, averaging 1,386 mg/L. Chloride ranges from 19.8 mg/L to 13,000 mg/L, averaging 2,639 mg/L. Fluoride ranges from 0.22 mg/L to 56.6 mg/L, averaging 4.20 mg/L. Sulfate ranges from 0.33 mg/L to 7,500 mg/L, averaging 1,633 mg/L. These water quality values are taken from the Main Base Flightline RI Report (Earth Tech, 1996). They are considered representative of hydrogeologic

conditions at OUs 1 and 6, which are adjacent on the Rogers Dry Lake shoreline and share the main runway.

(G) Potential to health risks caused by exposure to waste constituents:

The current and planned future use of NASA DFRC is industrial, for engineering flight research and testing. The HHRA (Earth Tech, 2003a), which included evaluation of the vapor intrusion to the indoor air pathway under the industrial scenario, concluded that groundwater poses no risk to the health of workers. Consumption of the groundwater would pose significant risk to human health. Because groundwater is shallow under some portions of OU6, excavation of trenches could pose risks to construction workers. This potential risk will be mitigated by the use of personal protective equipment.

(H) Potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents:

The ecological risk assessment found minimal risk to animal and plant receptors due to the industrial nature of the site, which is mostly paved. There is no agricultural production on or near OU6. Impact to physical structures has not been evaluated; none is expected.

(I) Persistence and permanence of the potential adverse effects:

Modeling predictions indicate that under a worst-case scenario, the selected remedy could take up to 130 years to restore groundwater to drinking water standards. However, significant reductions in contaminant concentrations have been accomplished by source removal actions, and reductions in extent due to natural attenuation in the diffuse, low-concentration areas of the plume have been observed and reported in several consecutive groundwater monitoring reports. Groundwater would not maintain its designated beneficial use for municipal and domestic supply until the cleanup levels are achieved. LUCs will be required to prevent exposure until unrestricted-use conditions are attained. This ROD contains provisions for land use covenants to be concluded by the Air Force in the event of transfer of the property at any time before such unrestricted-use conditions are attained.

Section 2550.4(d)(2), Subsections (A) through (J), contain a similar set of factors to be considered for surface water. There is no surface water at OU6 other than one retention basin in intermittent use to prevent surface runoff to the lakebed.

2.13.4.2 Analysis of Technical Feasibility

Any effective treatment system for near-term cleanup would entail extensive infrastructure installation and operation and ongoing maintenance activities in a heavily developed industrial area. Alternative 3 in the FS was developed as an aggressive plume-wide cleanup to reduce concentrations to the MCL for TCE (5 µg/L). It consists of two successive *in situ* chemical oxidation injection technologies (Fenton's reagent, followed by sodium permanganate), which was projected to reach MCLs within 10 years. Alternative 3 requires more than 2,500 injection wells and associated trenching and piping. Drilling, well installation, trenching, piping, and repeated injections would occur in buildings and taxiways, which would severely impact NASA DFRC's flight test and research mission. It is doubtful the mission could continue in the current location under those circumstances. This remedial alternative was based on a plume boundary defined on the MCL contour, which currently encompasses a surface area of 49.8 acres; defined on the 0.5 µg/L contour, the plume area (and volume) increases by 50 percent to 75.5 acres. Remediation efforts typically experience diminishing returns in diffuse low-concentration portions of plumes, particularly at the lowest concentrations such as between 5.0 µg/L and 0.5 µg/L, so it is reasonable to anticipate that progress will diminish asymptotically due to decreased desorption and reaction rates. This would require additional injections over the 50 percent additional area and an additional period of time, perhaps 10 more years, to remediate. This approach, while technically possible and likely to be effective, was judged infeasible to implement due to mission impacts.

Alternative 4 in the FS was designed as a less intrusive *in situ* chemical oxidation method incorporating injection of sodium permanganate into existing wells in high contaminant concentration areas and relying on natural processes of advection, dispersion, and diffusion to transport the reactants throughout the plume. The technical feasibility of Alternative 4 (the selected alternative), even with operation over an extended time, is greater than for Alternative 3 due to lower mission impact. However, the projected time to attain background levels also increases. The same considerations of 50 percent plume volume increase and diminishing returns apply as with Alternative 3. Fate and transport modeling conducted for the OU1 Main Base South Plume suggests that time to attain MCLs in the OU6 plume is 130 years. The modeling, incorporating physical and biological degradation mechanisms, indicates that the additional time required for remediation of the concentration increment from 5.0 µg/L to 0.5 µg/L is 115 years, for a total time of 245 years to reach background concentrations. While theoretically

feasible, the Air Force does not believe it is practical to commit to a remedial alternative requiring continuous management over such a time span.

2.13.4.3 Analysis of Economic Feasibility

The cost estimate of \$71.5 million for Alternative 3 (aggressive plume-wide cleanup to MCLs) accounted only for the specific labor and materials needed for the remedial infrastructure. Had costs of removing and replacing the impacted facilities and providing alternate workplaces, taxiways, and runways been accounted for, the cost would be much greater. Increasing the area to be treated by 50 percent would result in significant additional cost. Accounting for these additional factors, the cost would likely be in the range of \$700 million to \$1.4 billion. This results in a cost of \$1.2 million to \$2.4 million per pound to remediate the estimated 596 pounds of TCE (calculated mass within the 5.0 µg/L contour) in groundwater.

Aquifer tests conducted during the OU6 RI indicate that the yield of most wells is between 0.6 gpm and 2.5 gpm, with a maximum yield of 3.0 gpm (Earth Tech, 2000). This implies the aquifer can provide a maximum sustained yield of 4,320 gallons per day. Per capita consumption in California is estimated at 244 gallons per day (California Department of Water Resources [CDWR], 1998). Therefore, a well producing 3.0 gpm could provide up to 1.58 million gallons per year, sufficient water for four families. This is the benefit that would be realized within 10 years from implementing Alternative 3. The average price for delivered treated water by AVEK is currently \$274 per acre-foot (acre-ft) (winter \$239/acre-ft, summer \$309/acre-ft)(AVEK, 2006). A comparable volume of groundwater (50 acres, 90-foot assumed thickness) in drinkable condition today would have a market value of \$1.2 million. Assuming the groundwater reaches drinking water quality after 10 years, and using a 3 percent real rate of discount, the net present value of potable groundwater over 200 years (a standard time span for discounting a service into perpetuity, used here because there are no plans to use OU6 groundwater), is about \$32,500. This is the expected benefit from restoring the groundwater to drinking water standards. Based on this analysis, there is no economic benefit to continuing remediation to achieve background concentration levels.

In addition, there are currently no human or ecological receptors at OU6 or water supply wells downgradient from OU6. These calculations show that costs are not proportionate to benefits and

indicate that it is not economically feasible to clean up OU6 groundwater to MCLs or to background levels using Alternative 3.

If the economic analysis is based on extended implementation of Alternative 4 (less aggressive cleanup), feasibility increases. The present-worth cost estimated in the FS for Alternative 4 is only \$1.9 million. The actual cost is of course much higher, because the FS cost estimates consider only 30 years maximum in order to provide a comparison across all alternatives. The OU1 Main Base modeling mentioned above, which produces an increase in the projected time-to-cleanup from 130 years (to reach MCL) to 245 years (total time to reach background), indicates that costs would increase significantly but by an unknown amount; the near-doubling of the time span necessitates a proportional increase in injections, monitoring and reporting, and 5-year reviews. Due to the extended time-period, the expected benefit from restoring groundwater to MCLs is only \$743, while restoring to background levels would achieve no economic benefit. While theoretically feasible, the Air Force does not believe it is practical to commit to a remedial alternative requiring continuous management over such a time span.

2.13.4.4 Summary

Achieving background water quality using a more aggressive approach is technically possible but not technically or economically feasible due to unacceptable impacts to NASA DFRC's flight test and research mission and extremely high cost. Achieving background water quality using a less aggressive approach is technically possible but not technically or economically feasible due to uncertainties inherent in the extremely long treatment duration required. Continuing remediation beyond drinking water standards to achieve background concentrations incurs high costs and/or long time spans, achieves a small risk reduction, and results in no practical increase in the state's drinking water supply. In view of these considerations, drinking water MCLs are the most appropriate cleanup goals for OU6 groundwater restoration and are in the best interests of the people of the State of California.

2.13.5 COST-EFFECTIVENESS

The selected remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (40 CFR Part 300.430(f)(1)(ii)(D)). The

determination was made by evaluating the “overall effectiveness” of those alternatives that satisfied the threshold criteria (e.g., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness) to determine whether costs are proportional to the effectiveness achieved (Table 2-7). The overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, this alternative represents a reasonable value for the money to be spent.

All of the alternatives except Alternative 5 reduce the risk to human health and the environment by maintaining incomplete exposure pathways. Alternatives 1, 2, and 5 do not provide long-term effectiveness because they do not involve active remedial measures that decrease contaminant characteristics. Alternatives 3 and 4 provide active long-term effectiveness because they permanently reduce contaminant concentrations in the treated areas.

Alternatives 1, 2, and 5 do not treat contaminants and do not reduce the toxicity, mobility, or volume of VOCs in groundwater. Alternatives 3 and 4 reduce the volume and toxicity of contaminants in groundwater.

Minimal or no construction (well installation) is required for Alternatives 1, 2, 4, and 5. Potential short-term effects to workers, the public, and the environment are minimal for all alternatives. Alternatives 3 and 4 expose remedial contractors to very limited risk through exposure to chemical reagents.

The estimated present value costs of Alternatives 1, 2, and 5 are \$125,600, \$1,342,500, and \$0, respectively. Because they do not reduce the toxicity, mobility, or volume of groundwater contamination, they are not considered cost-effective. Although Alternatives 1, 2, and 5 are less expensive than the selected remedy, these alternatives do not treat the contaminants and are unlikely to comply with ARARs. Alternative 3 provides treatment of the entire plume, but at a cost that is 34 times higher than the selected remedy. The estimated present value cost of the selected remedy (Alternative 4) is \$1,905,800. Because it permanently reduces contaminant volume and toxicity, and restores groundwater quality, Alternative 4 is proportionally the most cost-effective in the long-term.

TABLE 2-7. RELEVANT CONSIDERATIONS FOR THE COST-EFFECTIVENESS DETERMINATION

Alternative (Ordered by Cost)	Present Value Cost	Long-Term Effectiveness and Permanence	Reduction of Contaminant Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness
5) No Action	\$0	^x Offers no active reduction in long-term risk to human health and the environment.	^x Offers no reduction in toxicity. ^x Offers no reduction in mobility. ^x Offers no reduction in volume.	^x Indefinite timeframe to achieve MCLs through natural processes. ^x No increase in short-term risk to workers. ^x No short-term risk to community. ^x No short-term risk to environment.
1) Land Use Controls	\$125,600	^x Offers no active reduction in long-term risk to human health and the environment.	^x Offers no reduction in toxicity. ^x Offers no reduction in mobility. ^x Offers no reduction in volume.	^x Indefinite timeframe to achieve MCLs through natural processes. ^x No short-term risk to workers. ^x No short-term risk to community. ^x No short-term risk to environment.
2) Groundwater Monitoring/Hydrologic Control	\$1,342,500	^x Offers no active reduction in long-term risk to human health and the environment.	¹ Offers no reduction in toxicity. ¹ Offers no reduction in mobility. ¹ Offers no reduction in volume.	¹ Indefinite timeframe to achieve MCLs through natural processes. ¹ No short-term risk to workers. ¹ No short-term risk to community. ¹ No short-term risk to environment.
4) <i>In Situ</i> Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring	\$1,905,800	² Offers active reduction in contaminant concentrations.	² Offers reduction in toxicity. ¹ Offers no reduction in mobility. ² Offers reduction in volume.	² At least 130 years to achieve MCLs through chemical oxidation and natural processes. Very limited short-term risk to workers.* ¹ No short-term risk to community. ¹ No short-term risk to environment.
3) <i>In Situ</i> Chemical Oxidation of the Entire Plume	\$71,458,900	² Offers more reduction in contaminant concentrations than previous alternative by treating a larger area.	² Offers reduction in toxicity. ¹ Offers no reduction in mobility. ² Offers reduction in volume.	² Less than 10 years to achieve MCLs through chemical oxidation. ¹ Very limited short-term risk to workers. ¹ No short-term risk to community. ¹ No short-term risk to environment.
Cost-Effectiveness Summary Alternatives 1, 2, and 5 are not cost-effective. Alternative 3 is not cost-effective due to the extremely high total cost. Alternative 4 is cost-effective and provides a potentially greater return on investment compared to Alternative 3.				

Notes:

^x baseline characteristic.

*Through use of personal protective equipment.

¹ No change compared to previous alternative.

² More effective compared to previous alternative.

MCL = maximum contaminant level
TCE = trichloroethene

2.13.6 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES

The selected remedy (Alternative 4) treats the groundwater at OU6, achieving significant reductions in contaminant concentrations in groundwater. The selected remedy satisfies the criteria for long-term effectiveness by degrading contaminants in groundwater and reducing toxicity and volume through treatment at a greater cost-benefit than the far more expensive Alternative 3. Alternatives 1, 2, and 5 provide for no treatment of contamination.

The selected remedy does not present significant short-term risks beyond those posed by any of the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated, other than the straightforward injection of reagent into the subsurface.

The selected remedy is the most cost-effective. It provides treatment of contaminants for a significantly lower cost than Alternative 3 and is acceptable by the USEPA and the State because it includes the treatment component. The community deemed the proposed alternative acceptable. The purge water generated during monitoring is the only waste stream, and it will be treated with carbon onsite and the treated effluent will be discharged to the Base sanitary sewer system. If permanganate is present in purge water generated from sampling activities, the purge water will be gravity fed into upgradient Site N2 wells in lieu of carbon treatment and discharge to the Base sanitary sewer system.

Of the alternatives that are protective of human health and the environment and comply with ARARs, the selected remedy provides the best balance of tradeoffs in terms of the five balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost), while also considering the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and considering regulatory agency and community acceptance. The selected remedy represents the maximum extent to which permanent solutions and treatment are practicable at OU6 given the extremely high cost and related lack of cost-effectiveness of Alternative 3.

2.13.7 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

By treating the groundwater in areas of highest contaminant concentrations, the selected remedy addresses the principal ARAR (MCL exceedances) through the use of treatment technology. By utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

2.13.8 FIVE-YEAR REVIEW REQUIREMENTS

A 5-year review will be conducted after 5 years and at 5-year intervals thereafter as long as hazardous substances remain at levels above levels that allow for unrestricted use and unrestricted exposure to ensure that the remedy continues to be protective of human health and the environment.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The OU6 PP (Earth Tech, 2005) was released for public comment in April 2005. The PP (Earth Tech, 2005) identified Alternative 4, Source Control and Hydrologic Control with Groundwater Monitoring, as the Preferred Alternative for groundwater remediation. Based upon the review of written and verbal comments submitted during the public comment period, no significant changes to the remedy, as originally identified in the PP (Earth Tech, 2005), are proposed. The selection of a different remedial alternative is not considered appropriate.

Only minor changes were implemented in this decision document: the RAOs were revised to include a performance-based cleanup goal (MCLs); for clarity, the title for Alternative 3 was revised from “Chemical Reaction” to “*In Situ* Chemical Oxidation of the Entire Plume”; and the title for Alternative 4 was revised from “Source Control and Hydrologic Control with Groundwater Monitoring” to “*In Situ* Chemical Oxidation of TCE Plume, Enhanced Natural Attenuation of Benzene Plume, Plume Containment, and Groundwater Monitoring”.

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3.0 RESPONSIVENESS SUMMARY

This Responsiveness Summary is intended to provide a summary of information about the views of the public regarding both the remedial alternatives and general concerns about OU6 submitted during the public comment period. Following the notice of the PP (Earth Tech, 2005) availability published in local newspapers in April 2005, the public comment period was held from 1 April to 1 June 2005 and public meetings were held on 27 April 2005 and 2 May 2005. No public comments impacted the decision-making process or the intended selection of the remedial approach.

3.1 STAKEHOLDER ISSUES AND LEAD AGENCY RESPONSES

Although the only written comment submitted during the public comment period questioned the suitability of the selected *in situ* chemical oxidation approach, the comment was a solicitation to provide services and offered no specifics regarding the perceived shortcomings of the implementation. The results of the public meetings indicated no adverse responses from the community.

3.1.1 ORAL COMMENTS

Comments and questions were solicited from the public regarding the proposed remedial action at OU6 during the 27 April 2005 and 2 May 2005 meetings. An interpretive summary of the comments and questions are presented below and the transcript from the 27 April 2005 meeting is available in the Administrative Record file for OU6. A very small group of citizens attended the 2 May 2005 meeting, and no questions regarding the proposed remedial action were received.

Paraphrased question: What volume of groundwater is impacted?

Answer: Based upon rough estimates generated during the FS (Earth Tech, 2004), the total volume of the contaminated groundwater is 45.5 million cubic feet, encompassing an approximate area extent of 50 acres.

Paraphrased question: How are chemical amounts estimated [for groundwater treatment] and are they aqueous?

Answer: The reagent volume and concentration are a function of the expected radius of influence, volume of water present within the treatment zone, and mass of VOCs present. For fractured bedrock applications, the amount of permanganate required for distribution through the treatment zone is generally 10 to 100 times higher than the stoichiometric oxidant demand estimated only from the VOC mass due to reactions of permanganate with naturally-occurring, oxidizable metals and organic matter present in the bedrock and aquifer and diffusion of permanganate into the bedrock fracture surfaces. The reagent is injected as a liquid.

Paraphrased question: Will permanganate treat aromatics?

Answer: No. Oxygen release compound will be used in the isolated area of benzene and permanganate will be used to treat chlorinated solvents such as TCE.

Paraphrased question: How are TCE contours estimated and plume maps generated?

Answer: Laboratory analytical results generated from groundwater sampling events are compiled in a database, concentrations are plotted spatially to generate isoconcentration contours on 2-dimensional maps, and data are interpolated or extrapolated for areas between wells.

Paraphrased question: How long has the plume been migrating?

Answer: An estimated 30 to 40 years have elapsed since the activities occurred that most likely contributed the materials that impacted groundwater.

Paraphrased comment: The injection of carbon dioxide into the subsurface may enhance recovery of purgeable aromatics.

Answer: For the benzene, toluene, ethylbenzene, and xylene compounds, the conditions observed in aquifers like the one beneath OU6 lend themselves to an aerobic bacterial decomposition of those

compounds. Oxygen and nutrients might be added, but carbon dioxide could prove to be counterproductive.

Paraphrased comment: Previous laboratory-based experimentation on bioremediation for other sites were unsuccessful when the organisms were released into the environment. Why would biological processes at OU6 yield different results?

Answer: The proposed remedial action does not entail introducing organisms to the aquifer below OU6. The bioremediation aspect of the proposed remedial action involves enhancing the environment for organisms already existing at the site through the addition of oxygen to groundwater impacted by contaminants.

Paraphrased question: How long will the remedial process take to complete?

Answer: The timeframe is unknown. Reviews will be conducted at 5-year intervals to verify the success of the action and to address shortcomings or the need to change the remedial approach.

Paraphrased question: What is the estimated cost of the preferred alternative?

Answer: Based on a 30-year remedial action, the estimated present value cost is \$1.9 million.

Paraphrased question: What type of cleanup is planned for soil?

Answer: None. Due to lack of complete exposure pathways to receptors from soil contamination, no remediation is proposed for soil.

Paraphrased question: What migration characteristics does the plume exhibit?

Answer: Because movement of the groundwater through the fractured bedrock is relatively slow, contaminant migration movement is also slow. At the leading edge of the plume the rate of advance is equal to that of the processes of dilution and dispersion, leading to a steady-state condition.

Paraphrased question: How long does the oxidation process take to reduce concentrations?

Answer: Destruction of the contaminants takes place immediately, within 69 minutes of contact with the reagent.

Paraphrased question: What is the ultimate concentration goal?

Answer: The goals are the respective MCLs for each contaminant, including 5 parts per billion for TCE.

Paraphrased question: Has *in situ* chemical oxidation been field tested?

Answer: Yes, *in situ* chemical oxidation treatability studies have been performed at Sites N3 and N7 with considerable success.

3.1.2 WRITTEN COMMENTS

The only written comment received was a letter dated 28 May 2005 from Mr. Marc Ashcroft representing Rejuvenate EKC, Inc. Although the letter is a solicitation to provide environmental services, the content has been addressed, to the extent possible, as commentary regarding the proposed remedial action at OU6.

3.1.2.1 General Subject

The main point of the letter appears to be that, although *in situ* chemical oxidation is considered by Mr. Ashcroft to be a viable technology for cleanup, permanganate is not the optimal reagent choice for OU6 and a different injection approach may be more appropriate. Mr. Ashcroft does not provide specifics regarding his reservations so a response to his commentary is not possible.

3.1.2.2 Specific Points

Paraphrased Comment: Use of permanganate will likely result in concentration rebound.

Answer: The treatment approach is iterative. If rebound occurs due to untreated groundwater flowing into treated areas, permanganate will again be injected.

Paraphrased Comment: A positive application of *in situ* chemical oxidation is possible with cost and time commitments.

Answer: Because the author provides no specifics regarding his recommended approach, the point cannot be addressed.

Paraphrased Comment: Proper application of *in situ* chemical oxidation is a dynamic, interactive process where placement of injection wells and quantities of injected reagents are played together to achieve optimal reduction. It is an in-the-field-hands-on application where process parameters are continuously monitored and used to regulate placement of the wells and quantities of the injected reagents.

Answer: The remedial design process has not been completed, the intent of the design, as with all remedial actions, will be to monitor effectiveness and adjust the approach accordingly - a dynamic application. Because the author provides no specifics regarding his recommended approach, the point cannot be further addressed.

Paraphrased Comment: Natural attenuation is slow, it requires continual monitoring, and one cannot commit to the time needed to reach the target cleanup levels.

Answer: Agree. This is why the timeframe is unknown and why natural processes will be augmented by *in situ* chemical oxidation.

Paraphrased Comment: The preferred alternative is not the dynamic application process required for a true *in situ* chemical oxidation.

Answer: Disagree. The remedial design process has not been completed, the intent of the design, as with all remedial actions, will be to monitor effectiveness and adjust the approach accordingly - a dynamic application. Because the author provides no specifics regarding his recommended approach, the point cannot be further addressed.

Paraphrased Comment: In analyzing Alternative 4, one reaches the understanding that it is essentially a natural attenuation process augmented with an *in situ* chemical oxidation factor for good measure.

Answer: Agree. The initial intent of the remedial design is to use *in situ* chemical oxidation in conjunction with natural processes, to be adjusted based upon field conditions and trends.

Paraphrased Comment: The method currently selected to treat the subject site is not certain to produce the desired outcome. It is also my opinion that the cost predicted for this method is not certain because there is no time frame committed.

Answer: Because the author provides no specifics regarding an approach that will better produce the desired results, the point cannot be addressed. The cost summaries provided are preliminary and will be further refined during the remedial design phase of the project.

Paraphrased Comment: There is a way to handle the entirety of the contamination at the site, in the soil and groundwater, for a cost substantially lower than \$71.5 million.

Answer: The author's estimate of the areal extent of the plume (15 acres) differs considerably from the estimates presented in the Proposed Plan (approximately 50 acres). Because the author provides no specifics regarding an approach that would more efficiently handle the entirety of the contamination at the site, the point cannot be addressed.

3.2 COMPREHENSIVE RESPONSE TO TECHNICAL AND LEGAL ISSUES

Responses to comments posed by the community have been addressed with sufficient detail in the preceding section. No additional specific legal or technical questions have been identified.

3.3 REMAINING CONCERNS

No additional concerns have been identified.

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APPENDIX A

SUMMARY OF ARARS IDENTIFIED FOR OU6

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Item No.	Requirement	Citation	Federal, State or Local Requirement	Description	ARAR Determination	Comments	Applicable Sites
Chemical-specific ARARs							
1	Primary Drinking Water Standards (Non-zero MCLGs and MCLs)	Safe Drinking Water Act, 40 CFR Part 141, Sections 141.11, 141.50-.51, 141.61-.62 40 CFR Part 300, Sections 300.430(e)(2)(i)(C) 22 CCR, Div. 4, Ch. 15, Articles 4, 4.5, and 5.5, Sections 64431 et seq., 64444	Federal State	MCLGs are goals under the SDWA which are set at levels at which no adverse health effects will occur and allow an adequate margin of safety. MCLs are promulgated and enforceable maximum concentrations of drinking water priority pollutants that are set as closely as feasible to MCLGs, considering best technology, treatment techniques, and other factors. The NCP states that primary drinking water standards are legally applicable only to drinking water at the tap, but are relevant and appropriate as cleanup standards for groundwater and surface water that have been determined to be current or future drinking water sources. Under CERCLA 121(d)(2)(A), remedial actions shall attain MCLGs where relevant and appropriate. The NCP provides that where an MCLG has been set at a level of zero, the MCL for that contaminant shall be attained. Establishes standards for public water supply systems, including primary MCLs. State MCLs must be at least as stringent as Federal MCLs. State MCLs are incorporated into State and Regional Water Quality Board Water Quality Control Plans as water quality objectives for protection of current and potential drinking water supply sources. MCLs are some of the applicable upper-end objectives for ambient ground and surface water where the water is a source of drinking water, as defined in the Water Quality Control Plans.	Relevant and appropriate	This regulation addresses drinking water-based cleanup goals for groundwater plumes at OU6. The AF and State agree, in this particular case, that use of MCLs as cleanup standards, in conjunction with Institutional Controls, is protective of human health at OU6. Only State MCLs that are more stringent than Federal MCLs are ARARs. For the constituents at OU6, there are no State MCLs that are more stringent than Federal MCLs.	N2, N3, and N7
2	Policies and Procedures for Investigation and Cleanup and Abatement	SWRCB Resolution No. 92-49. Water Code Sections 13140, 13240, 13304, 13307	State	State Board Resolution No. 92-49 establishes policies and procedures for the oversight of investigation and cleanup and abatement activities resulting from discharges of waste which affect or threaten water quality. It requires cleanup of all waste discharged and restoration of affected water to background conditions (i.e., the water quality that existed before the discharge). Requires actions for cleanup and abatement to conform to Resolution No. 68-16, water quality control plans and policies, and applicable provisions of California Code of Regulations, Title 23, Division 3, Chapter 15 (Discharges of Hazardous Waste to Land) as feasible.	Relevant and appropriate	Section III.G of Resolution 92-49 is relevant and appropriate. The AF has performed a TEFA for groundwater at OU6 to satisfy requirements for corrective action under SWRCB Resolution 92-49. The AF and the State agree that the cleanup standards for groundwater, in this particular case, are MCLs.	N2, N3, and N7
3	Water Quality Control Plan, South Lahontan Basin (Basin Plan)	23 CCR Div. 4, Ch. 1, Article 6, Section 3950; Water Code Sections 13140 and 13240	State	The Porter-Cologne Water Quality Control Act established authority of the SWRCB and RWQCB to regulate discharges into Waters of the State. The Basin Plan establishes beneficial uses and the water quality criteria based upon such uses (water quality objectives). The Basin Plan serves to protect the beneficial uses and water quality of the surface and groundwater in the South Lahontan Basin.	Relevant and appropriate	The water quality objectives for chemical constituents in groundwater are relevant and appropriate.	N2, N3, and N7

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Item No.	Requirement	Citation	Federal, State or Local Requirement	Description	ARAR Determination	Comments	Applicable Sites
Location-specific ARARs							
4	California Endangered Species Act	CDFG Code Section 2050-2055; 14 CCR Div. 1, Subdivision 3, Ch. 6 Section 783.1	State	Establishes species, subspecies, and varieties of native California plants or animals as endangered, threatened, or rare. Prohibits the taking, importation, or sale of any species, or any part thereof, of an endangered species or a threatened species. Contains provisions concerning CDFG coordination with State and Federal agencies and with project applicants. Recommends avoidance of adverse impacts on species of special concern and their habitat.	Relevant and appropriate	Potentially an ARAR where the State law has a listing that is more stringent than the Federal Endangered Species Act and Migratory Bird Treaty Act. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. State may provide procedures for minimization of impacts and harm to species.	All
5	Fish and Wildlife Protection and Conservation	CDFG Code Section 1600-1607 (except 1606); 14 CCR, Div. 1.5, Ch. 4, Subchapter 4, Sections 916, 916.2, Subchapter 5, Sections 936, 936.2, and Subchapter 6 Sections 956, 956.2	State	Declares the protection and conservation of fish and wildlife to be an important public interest. Section 1602 prohibits substantial diversion or obstruction of the natural flow of, or substantial change or use of any material from the bed, channel, or bank of, any river, stream, or lake, or deposition or disposal of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake without prior notification and approval from CDFG. This section is a general statement of policy that does not impose a substantive requirement. Rather it imposes a reporting requirement when stream diversion, dredging, or waste disposal affecting fish and wildlife is to take place.	Relevant and appropriate	Remedial action must be protective and conserve fish and wildlife resources. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. State may provide procedures for minimization of impacts and harm to species.	All
6	Wildlife Species/Habitats	CDFG Code Sections 2000, 2014, 3005, 3511, 3513, and 12000 et seq. 14 CCR, Div. 1, Subchapter 2, Section 250, Section 507; Subchapter 3, Section 650	State	Prohibits the taking of birds and mammals. This code section imposes a substantive, promulgated environmental protection requirement covering destruction of wildlife caused by unlawful discharges of pollutants to waters of the State in violation of Division 7 (Section 13000 et seq.) of the Water Code.	Relevant and appropriate	As stated in Air Force Instruction 32-7064, dated 17 September 2004, State protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. State may provide procedures for minimization of impacts and harm to species.	All
7	Mammals and Reptiles Provisions	CDFG Code Sections 4700 and 5050; 14 CCR, Div. 1, Subdivision 3, Ch. 3, Section 670	State	Prohibits the possession of mammals and reptiles that are identified as “fully protected.”	Relevant and appropriate	Potentially applicable where the State law has a listing that is more stringent than the Federal and State Endangered Species Act or Migratory Bird Treaty Act. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. State may provide procedures for minimization of impacts and harm to species.	All
8	Rare Native Plants	CDFG Code Sections 1900 et seq. and 2080; 14 CCR, Div. 1, Subdivision 3, Ch. 6, Section 783	State	Contain provisions concerning native plant protection including: criteria for determining endangered plant species; designation of endangered plants; and other prohibitions.	Relevant and appropriate	As stated in Air Force Instruction 32-7064, dated 17 September 2004, State protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. State may provide procedures for minimization of impacts and harm to species.	All

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Item No.	Requirement	Citation	Federal, State or Local Requirement	Description	ARAR Determination	Comments	Applicable Sites
Action-specific ARARs							
9	Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262 22 CCR, Div. 4.5, Ch. 12, Articles 1-4, Sections 66262.10-.47	Federal State	These regulations apply to generators of hazardous waste. Edwards AFB is a large quantity generator of hazardous waste (EPA ID CA1570024504) and already subject to these requirements. Establishes standards for generators of RCRA and ¹ California hazardous wastes, including those for hazardous waste determination, accumulation, identification numbers, manifesting, pre-transport, and record keeping and reporting requirements.	Applicable if soil cuttings, purge water or spent carbon are hazardous waste.	Applicable to waste generated (soil cuttings, purge water from groundwater sampling, and spent carbon from onsite treatment of purge water) as part of OU6 groundwater remedies if these wastes are hazardous. Substantive requirements are potentially ARARs if excavated soils or treatment residuals exceed RCRA or ¹ California hazardous waste thresholds. Hazardous remediation waste may be stored onsite in Corrective Action Temporary Units. These Corrective Action Temporary Units are not subject to the less than 90-day accumulation time requirement. Temporary units may operate for 1 year with an opportunity for a 1-year extension.	Soil cuttings, purge water, and spent carbon generated from groundwater monitoring of Sites N2, N3, and N7 plumes
10	Underground Injection Control Program	40 CFR Parts 144, 146, 147, Sections 144.13(c) 144.82-.83, 144.89; Sections 146.5 and 146.10; Section 147.251	Federal	Protects groundwater from contamination by subsurface emplacement of fluids. According to Section 144.13(c), wells used to reinject contaminated groundwater that has been treated into the same formation from which it was drawn are not prohibited if such injection is approved by EPA, or a State, pursuant to provisions for cleanup of releases under CERCLA, 42 U.S.C. 9601-9657, or pursuant to requirements and provisions under RCRA, 42 U.S.C. 6901 through 6987. Wells for injection of treatment chemicals or treated groundwater into shallow wells are designated Class V wells according to Section 146.5. Section 144.82 prohibits the movement of fluid containing any contaminant into an underground source of drinking water if it would cause a violation of primary drinking water standards under 40 CFR Part 141, or other health-based standards, or may otherwise adversely affect the health of persons. Injection well closure must prohibit emplaced fluid movement. States and EPA Regions can establish more stringent requirements if needed to protect underground sources of drinking water. Section 144.83 specifies inventory requirements for the operation of the injection well. Section 144.89 contains well closure requirements. Section 146.10 contains well plugging and abandonment requirements. Section 147.251 states that EPA administers the UIC program in California for Class V wells.	Applicable	Substantive portions are applicable to the injection of sodium permanganate or other oxidizing chemicals in the Sites N2, N3, and N7 plumes. Reinjection of treated groundwater qualifies for the exemption in Section 144.13(c) for groundwater treatment systems.	N2, N3, and N7

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Item No.	Requirement	Citation	Federal, State or Local Requirement	Description	ARAR Determination	Comments	Applicable Sites
11	Statement of Policy with Respect to Maintaining High Quality of Waters in California (Non-degradation Policy)	SWRCB Resolution Number 68-16 (23 CCR Section 2900)	State	Resolution No. 68-16 (anti-degradation policy) has been incorporated into all Regional Board Basin Plans, including the Lahontan Water Board's Basin Plan. This resolution requires that the quality of waters of the State that is better than needed to protect all beneficial uses be maintained unless certain findings are made. Discharges to high quality waters must be treated using best practicable treatment or control necessary to prevent pollution or nuisance and to maintain the highest quality water. This resolution also requires cleanup to background quality or lowest concentrations technically and economically feasible to achieve. Beneficial uses, at minimum, must be protected.	Applicable	State Water Resources Control Board Resolution 68-16 is an ARAR for the injection or reinjection of sodium permanganate, any treatment chemicals, or any reagent into groundwater to treat contaminants.	N2, N3, and N7
12	Sources of Drinking Water Policy	SWRCB Resolution No. 88-63; Porter-Cologne Water Quality Act (CWC Sections 13000, 13140, 13240); H&S Code Section 25356.1.5 (a)	State	Resolution 88-63 has been incorporated into all Regional Board Basin Plans, including the Lahontan Water Board's Basin Plan. This resolution designates all ground and surface waters of the State as drinking water except where the TDS is greater than 3,000 ppm, the well yield is less than 200 gpd from a single well, the water is a geothermal resource or in a waste water conveyance facility, or the water cannot reasonably be treated for domestic use using either best management practices or best economically achievable treatment practices.	Applicable	The AF agrees with the designation of the current and potential use of the groundwater for this OU as drinking/domestic use.	N2, N3, and N7 groundwater remedial action
13	Definition of and Criteria for Identifying Hazardous Wastes	40 CFR 261.3 22 CCR, Div. 4.5, Ch. 11, Article 1, Sections 66261.2-.3; Articles 3, Sections 66262.24 -.33; Article 5, Sections 66261.100-.101	Federal State	Defines wastes that are subject to regulation as a RCRA or ¹ California hazardous waste. Excavated contaminated soil, extracted groundwater, and spent treatment residuals (e.g., granular activated carbon) must be classified using AF knowledge of the timing and nature of the release as well as waste toxicity characteristic testing. If, after good faith effort, the AF determines that the contaminated soil or groundwater contains a listed RCRA or ¹ California hazardous waste or fails the Federal or State toxicity characteristic tests, then the excavated soil or extracted groundwater is considered hazardous based on EPA's "contained-in" policy and must be managed as hazardous remediation waste. Contaminated soils or groundwater that are treated <i>in situ</i> are not subject to the identification or classification requirements.	Applicable	The definitions of hazardous waste in Article 1 and toxicity characteristic criteria (i.e., TTLC and STLC levels) in Section 66261.24 are applicable for the characterization of soil cuttings from well installation, as well as purge water and spent carbon from groundwater monitoring and onsite water treatment. The soil cuttings are not expected to be hazardous. Treated purge water that is discharged to the Base sanitary wastewater treatment facility will no longer be hazardous waste and will be subject to discharge limits based on the facility's discharge permit limits. Spent carbon will be tested prior to off-site disposal or regeneration.	Onsite purge water treatment at Sites N2, N3, and N7
14	Hazardous Waste Land Disposal Restrictions	40 CFR Part 268 22 CCR, Div. 4.5, Ch. 18, Section 66268	Federal State	Identifies hazardous wastes that are restricted from land disposal without prior treatment to UTS. Hazardous remediation wastes that are managed off-site are subject to the LDR UTS specified in Section 66268 for wastewater (liquid) and non-wastewater (solid). Hazardous soils must be treated to 90% reduction in concentration capped at 10 times the UTS for principal hazardous constituents (90% capped at 10 x UTS). On-site treatment or disposal of hazardous remediation wastes are not strictly subject to the LDR treatment standards, but are subject to similar treatment standards specified in the Corrective Action Management Unit Amendment Rule codified in 40 CFR 264.550-.555 and 22 CCR 66264.550-.553.	Applicable	LDR applicable to off-site disposal of soil cuttings, treated groundwater, and spent carbon if these remediation wastes are RCRA or ¹ California hazardous waste, as determined through toxicity characteristic testing using TCLP and TTLC/STLC.	Offsite disposal of hazardous remediation wastes from Sites N2, N3, and N7

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Item No.	Requirement	Citation	Federal, State or Local Requirement	Description	ARAR Determination	Comments	Applicable Sites
15	Land Use Controls	22 CCR, Div. 4.5, Ch. 39, Section 67391.1, Civil Code Section 1471, a & b	State	<p>Requires that if a remedy will result in hazardous substances remaining on a property at levels not suitable for unrestricted use, the limitations or controls are clearly set forth and defined in the response action decision document, and that the decision document include an implementation and enforcement plan.</p> <p>In the event of a property transfer, requires the state to enter into restrictive land use covenants with land-owners and their successors under such circumstances, with exceptions for federal-to-federal property transfers.</p>	Relevant and appropriate	<p>Institutional controls, limiting exposure to contaminated groundwater, are required at OU6 until hazardous substance concentrations in groundwater are suitable for unrestricted use.</p> <p>Although it is not contemplated that property at OU6 will be transferred, in the event that such property is transferred, the AF and the State have agreed to follow the procedure laid out in Section 2.12.2.1 LUC of this ROD.</p>	All portions of OU6 groundwater plumes with original sources at N2, N3, and N7 requiring institutional controls

TABLE A.1. ARARS - OPERABLE UNIT 6, EDWARDS AFB, CA
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Notes:

¹California hazardous waste (as used in this table) is the same as non-RCRA hazardous waste as defined in Section 66261.101 of CCR Title 22.

AF	=	Air Force
AFB	=	Air Force Base
ARARs	=	Applicable or Relevant and Appropriate Requirements
Basin Plan	=	Water Quality Control Plan for Lahontan Region
CCR	=	California Code of Regulations
CDFG	=	California Department of Fish and Game
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	=	Code of Federal Regulations
Ch.	=	Chapter
CWC	=	California Water Code
Div.	=	Division
e.g.	=	<i>exempli gratia</i> (for example)
EPA	=	Environmental Protection Agency
et seq.	=	<i>et sequentes</i> (and the following)
gpd	=	gallons per day
H&S	=	health and safety
IC	=	institutional control
ID	=	identification
i.e.	=	<i>id est</i> , that is
LDR	=	land disposal restriction
MCL	=	Maximum Contaminant Level
MCLG	=	Maximum Contaminant Level Goal
NCP	=	National Contingency Plan
No.	=	number
OU6	=	Operable Unit 6

ppm	=	parts per million
RCRA	=	Resource Conservation and Recovery Act
ROD	=	Record of Decision document
RWQCB	=	Regional Water Quality Control Board
SDWA	=	Safe Drinking Water Act
STLC	=	soluble threshold limit concentration
SWRCB	=	State Water Resources Control Board
TCLP	=	toxic characteristic leaching procedure
TDS	=	total dissolved solid
TEFA	=	Technical and Economic Feasibility Analysis
TTLC	=	total threshold limit concentration
UIC	=	Underground Injection Control
U.S.C.	=	United States Code
UTS	=	universal treatment standard